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# SCIENCE POLICY STUDY
# BACKGROUND REPORT NO. 8

# SCIENCE SUPPORT BY THE DEPARTMENT OF DEFENSE

REPORT

PREPARED BY THE

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**Serving on Committee on the Budget for 99th Congress.

# LETTER OF TRANSMITTAL

House of Representatives,
Committee on Science and Technology,
*Washington, DC, September 8, 1987.*

*To the Members of the Science Policy Task Force:*

A review of the Federal government's support of scientific research since the end of World War II cannot be adequately done without a thorough consideration of the role that has been played by the Department of Defense and its many components. The present Study provides a wealth of information about the history, policies, and past, present and future impact of Defense Department's role in the conduct and support of basic and applied scientific research.

Entitled "Science Support by the Department of Defense", the Study will, we believe, provide a useful and much needed perspective on the many factors which impinge on the policies that govern support for scientific research in the Defense Department, and the many effects, both within the defense research community and in the civilian science community, which flow from those policies, practices, and activities. The concerns which have been expressed in some universities about the recent growth of defense department funding for campus research, can be seen as part of the cyclical view with which defense research activities have been viewed by American scientists. It thus enables us to take the longer term view of American science policy which is the principal aim of the Science Policy Study.

The Science Policy Research Division of the Congressional Research Service has done a fine job of bringing together the many threads which constitute the fabric of U.S. defense research policy. Through the coordination of Ms. Genevieve J. Knezo, who herself wrote many of the chapters, a team of able researchers and analysts have made this Background Study possible. To them we express our thanks for the extensive and valuable effort that is reflected in the following pages.

We commend this Study to the attention of the members of the Science Policy Task Force, the members of the Committee on Science and Technology, and all our colleagues in the Congress.

Manuel Lujan, Jr.,
*Ranking Republican Member.*

Robert A. Roe, *Chairman.*

# LETTER OF SUBMITTAL

CONGRESSIONAL RESEARCH SERVICE,
THE LIBRARY OF CONGRESS,
*Washington, DC, July 29, 1987.*

Hon. ROBERT ROE,
*Chairman, Committee on Science, Space, and Technology, House of Representatives, Washington, DC.*

DEAR MR. CHAIRMAN: I am pleased to submit this report entitled "Science Support by the Department of Defense," prepared at the request of the Committee on Science and Technology for the Task Force on Science Policy.

The report examines historical, organizational, financial, and policy questions about military research and its implications for national security, the scientific and technical infrastructure, and the economy. Among the specific aspects of military research covered are: research performance by universities, industry and intramural laboratories; funding trends; independent research and development; mechanisms for priority setting and evaluation; effects of national security issues on the conduct of military research in universities; utilization of scientific and technical personnel; scientific advisory committees; and impacts of military research on science and on the economy.

Ms. Genevieve J. Knezo, Specialist in Science and Technology, coordinated the effort and also wrote several chapters of the study. Other contributors are Michael E. Davey, Analyst in Science and Technology; Wendy Schacht, Specialist in Science and Technology; Joan D. Winston, formerly Senior Research Assistant; and Christopher T. Hill, Senior Specialist in Science and Technology. Production support was provided under the supervision of Ms. Shirley Williams by Ms. Sandra Burr, Ms. Karina Bush, and Ms. Kaseem Hall.

We hope that this report will be useful in your deliberations and appreciate the opportunity we had to conduct this challenging study.

Sincerely yours,

JOSEPH E. ROSS, *Director.*

# CONTENTS

Page
Letter of Transmittal ..... III
Letter of Submittal ..... V
Contents ..... VII
Tables, Charts, and Figures ..... XI
Chapter I, Introduction and Purpose of the Study ..... 1
Chapter II, Summary and Overview of Policy Issues Raised in the Study ..... 3
  A. Definitions ..... 3
  B. History ..... 3
    1. Impact of Military Research on Civilian Government-Science Relationships ..... 4
    2. Historical Factors Shaping DOD Organization for Research Support ..... 4
  C. Funding Trends and the Civilian/Military Balance for R&D ..... 5
  D. Are DOD Budgets for Basic Research Adequate? ..... 7
  E. Performers of Military Research ..... 9
  F. Should Links Be Improved Between Research Investment Choices and Military Needs ..... 9
    1. Is More Attention Required to Set Research Agendas and to Coordinate Federal Research Funding? ..... 10
    2. Impact of Defense Research Spending on Science ..... 11
    3. Multi-Year Funding ..... 12
  G. Is Defense Technology Too Sophisticated? ..... 12
  H. Research Procurement and the Effect of the Competition in Contracting Act ..... 13
  I. The Role of DARPA ..... 14
  J. Military Research at the Nation's Colleges and Universities ..... 14
    1. Rapidity of Funding Increases ..... 15
    2. Impact on Academic Research Priorities ..... 15
    3. "Spinoffs" ..... 16
    4. Effects of Budgets on Campus Research ..... 16
    5. DOD Support for Academic Infrastructure ..... 17
    6. University/Industry Relationships ..... 17
  K. Implications of the Strategic Defense Initiative Program ..... 17
  L. DOD Research Performed in Universities and National Security Controls ..... 18
  M. Scientific and Technical Personnel ..... 19
  N. Improvements Needed in Military Laboratories ..... 21
    1. Issues Relating to Research Priorities, Review, and Performance ..... 21
    2. Issues Relating to Laboratory Personnel ..... 23
  O. The Scientific Advisory System of the Department of Defense ..... 24
  P. DOD Support of RDT&E in Industry ..... 24
    1. Balance of Performers ..... 26
    2. Technological Priorities ..... 26
    3. Decisionmaking for Weapons R&D ..... 26
    4. Effective Use of Performers ..... 26
    5. Security Classification ..... 27
    6. Spin-off to the Civilian Sector ..... 27
  Q. DOD Support for Independent Research and Development in Industry.. 27
  R. Impact of Defense Research Spending on Economic Growth and Competitiveness ..... 29
    1. Debates About the Impact of Military R&D on the Economy ..... 29
    2. Impacts of Defense R&D on Productivity ..... 30
    3. Technology Transfer ..... 31

Page
Chapter II, Summary and Overview of Policy Issues Raised in the Study—Continued
R. Impact of Defense Research Spending on Economic Growth and Competitiveness—Continued
4. Geographic Concentration and Economic Effects of Military R&D Spending ..... 31
Chapter III, Department of Defense Research in Historical Context ..... 33
A. Introduction ..... 33
B. Military Research During World War I and World War II ..... 36
C. An Overview of the Evolution of the Organization of Military Research and Its Impact on Civilian Science/Government Relationships ..... 37
1. Funding Mechanisms ..... 37
2. The Development of Governmental Confidence About Using Science and Technology for National Purposes ..... 39
3. Creation of the National Science Foundation ..... 40
4. Creation of Other Agencies ..... 40
D. Creation of the DOD Research Structure ..... 41
E. Creation of Federally Funded Research and Development Centers ..... 42
F. The Services' Research Structures ..... 46
G. The Curtailment of the National Science Foundation's Military Research Function ..... 48
H. Activities Related to the Korean War ..... 48
I. Activities Following the Launch of Sputnik in 1957 ..... 50
1. Creation of NASA ..... 50
2. National Defense Education Act ..... 50
3. White House Science Office ..... 51
4. Creation of Advanced Research Projects Agency ..... 51
J. Organization of the DOD Following the Launch of Sputnik ..... 52
K. Criticism of Military-Industrial Complex ..... 54
L. Criticisms of Military Research Funding ..... 55
1. Cutback in University Research ..... 55
2. Project Camelot ..... 56
3. Relevancy Requirements; Mansfield Amendment ..... 57
M. Recent Events ..... 59
N. Concluding Comments ..... 63
Chapter IV, Military Research Funding Trends and Processes ..... 65
A. Definitions and Trends ..... 65
1. Categories of RDT&E ..... 66
2. Technology Base Activities ..... 72
3. Funding for RDT&E Accelerated Significantly in the 1980s ..... 73
4. Relative Decline in Funding for Research ..... 74
5. Research Performers ..... 81
6. Priorities for Long- vs. Short-Term Research ..... 89
7. Military Research Funding by Discipline ..... 89
B. Organization for Research Management ..... 90
1. Functions of the Under Secretary for Defense Research and Engineering and of the Office of the Director of Defense Research and Engineering ..... 90
2. The Army ..... 92
3. The Navy ..... 97
4. The Air Force ..... 99
5. The Defense Advanced Research Projects Agency (DARPA) ..... 101
a. DARPA's Objectives ..... 101
b. DARPA's Funding Mechanisms and Products Are Praised ..... 105
c. Criticism of DARPA ..... 106
C. The Importance of the Soviet Threat in Program Formulation ..... 108
1. Goals of DOD Science and Technology Mission Defined In Response to Military Threats ..... 108
2. Allegations That the United States Overreacts to the Soviet Threat ..... 112
D. Military Research Funding Mechanisms and Procedures ..... 113
1. The Army ..... 116
2. The Navy ..... 116
3. The Air Force ..... 116
4. Cluster Programs ..... 117
5. Research Review Processes ..... 118
6. Contracting ..... 118
E. Alleged Inefficiencies in Military Research Planning and Production ..... 120

Page

Chapter IV, Military Research Funding Trends and Processes—Continued

E. Alleged Inefficiencies in Military Research Planning and Production—Continued

1. Possible Inefficiencies in Research and Technology Development Caused by Interservice Rivalry ... 121
2. Possible Inefficiencies Caused by Problems in Linking Research Investment to Military Needs ... 122
3. Issues Relating to Alleged Duplication of Research ... 123

F. Additional Issues About the Conduct and Utility of Military Research ... 126
1. Is There a Need for More Long-Range Defense Research ... 126
2. Multiyear Funding ... 127
3. Changes Recommended for DARPA ... 128
4. Termination of the Office of Under Secretary for Research and Engineering ... 128
5. The "High-Technology" vs. "Low-Technology" Debate ... 129

G. Concluding Observations ... 130

Chapter V, Overview of DOD Support for Research at Colleges and Universities ... 133
A. Introduction ... 133
B. Post-War History ... 134
C. DOD's Loss of Influence ... 136
D. The Decline of Funding Support ... 146
E. DOD Back on Campus ... 148
F. DOD Support of University Research Infrastructure ... 155
G. DOD Educational Programs ... 160
H. DOD Support of Research by Field of Science ... 161
I. Issues Related to DOD Funding of R&D at Universities ... 168
J. Conclusion ... 174

Chapter VI, The Role Played by the DOD Laboratory Structure in the Conduct and Support of Research ... 177
A. The Setting ... 177
B. The Rationale for Research ... 178
C. Operations ... 180
1. Funding ... 181
2. Extramural Research Support ... 186
3. Performance Evaluation ... 186
4. Laboratory-Command Interaction ... 187
5. Chain of Command ... 188
6. Personnel and Manpower ... 189
7. Technology Transfer ... 191

D. Concluding Observations ... 193
Appendix A, Department of Defense In-House RDTE Activities ... 196

Chapter VII, Department of Defense Support of RDT&E in Industry ... 279
A. Introduction ... 279
B. The Place of DOD in Federal Support of R&D in Industry ... 280
C. DOD Structure and Organization for RDT&E in Industry ... 284
D. Technology Base Work Performed by Industry ... 287
E. Industrial R&D Performers and the Role of RDT&E in Industry ... 291
F. Four DOD Industrial RDT&E Initiatives ... 300
1. The Very High Speed Integrated Circuits (VHSIC) Program ... 301
2. The Strategic Computing Initiative ... 305
3. The DOD Manufacturing Technology Program (ManTech) ... 307
4. The Small Business Innovation Research Program in DOD ... 310
a. Overview of SBIR ... 310
b. The SBIR Program in DOD ... 312
c. Projects Funded Under DOD SBIR ... 314

G. Issues Concerning DOD Sponsorship of R&D in Industry ... 314
1. Overview ... 314
2. Selected Issues for Congressional Consideration ... 315

H. Concluding Observations ... 318

Chapter VIII, DOD Support of Independent Research and Development (IR&D) in Industry: Issues and Implications for Federal Support of Civilian R&D ... 321
A. Introduction ... 321
B. Costs of IR&D ... 323
1. Mechanisms of IR&D Reimbursement ... 323
2. Relationship of IR&D to Bid and Proposal Costs ... 324
3. Sources of IR&D Cost Data ... 324

Page

Chapter VIII, DOD Support of Independent Research and Development (IR&D) in Industry—Continued

B. Costs of IR&D—Continued

4. IR&D Cost Data, 1964-1984 325
5. Analysis of IR&D Data by Industry and Purpose 329
6. Trends in DOD Shares of Allocated IR&D Costs 330
C. Recurring Policy Issues Regarding IR&D 332
D. Measuring the Outcomes from IR&D 335
E. Contrasts Between IR&D and Other Means of R&D Support 339
F. Current and Potential Uses of the IR&D Mechanism in Civilian R&D 343
1. IR&D in Civilian Agencies: NASA, AEC, and FAA 344
a. National Aeronautical and Space Administration 344
b. Atomic Energy Commission/Department of Energy 346
c. Federal Aviation Administration 347
2. IR&D in Federally Supported University Research 347
a. IR&D Reimbursements to Universities: the Major Issues 347
b. Proposed 1981 Modification of OMB Circular A-21 to Include IR&D 348
c. Current Status of IR&D Under OMB Circular A-21 352
d. Other Approaches to Federal Support of University Research Capacity 353
e. Bid and Proposal Costs (B&P) 355
f. Concluding Observations 356
G. Summary of Issues Regarding IR&D 356
Chapter IX, The Impacts of DOD Research Policies on U.S. Scientific and Technical Personnel 359
A. Historical Views 360
B. Current Estimates of Military Utilization of the Nation's Scientists, Engineers, and Technicians 360
C. Effects of Military Demand on the Supply of Scientific and Technical Personnel 361
1. Demands Placed on Specific Technical Fields 361
2. Implications for Military Manpower 364
3. The "Spillover" Argument 364
D. Activities Undertaken By the Military to Increase the Nation's Supply of Scientists and Engineers 365
1. Direct Funding of University Research and Graduate Students 369
2. Faculty Support 370
3. College Faculty and Student Support 370
4. Graduate Students 370
5. High School Students 370
E. Support of University Research Capability 370
1. University Research Instrumentation 371
2. DOD-University Initiative 371
3. University/Industrial Cooperation 371
4. Other Programs 372
5. Programs Described According to Service 372
F. Concluding Observations 372
Appendix 373
DOD Science and Engineering Education Programs 373
Selected Army Education Programs 374
Selected Navy Education Programs 375
Selected Air Force Education Programs 376
Chapter X, DOD Research Performed in Universities and National Security Controls 379
A. Introduction 379
B. Background 380
C. An Easing of Controls 385
D. The Concept of National Security 387
E. The Contemporary Setting 389
F. Controlling Open Communication of Scientific Research 394
G. Impacts on Colleges and Universities 397
H. The Spill-Over Effect 400
I. Secrecy and Commercial Spinoffs 403
J. Conclusion 404
Chapter XI, Scientific Advisory System of the Department of Defense 405
A. Introduction 405
B. The Defense Science Board 406

Page

Chapter XI, Scientific Advisory System of the Department of Defense—Continued

B. The Defense Science Board—Continued

1. Creation and Evolution of Membership Structure 406
2. Functions 407
C. Inventory of Defense Science Board Activities 408
D. The Services' Advisory Committees 411
E. Criticisms of the Potential Bias of the Defense Science Board and Other Advisory Bodies 412
F. Issues About the Utility of DSB Reports 415
G. Other Advisory Mechanisms 416
1. The Jason Group 416
2. Contracted Advisory Services 417
3. The DOD-University Forum 417
4. OST and Other White House Advisory Groups 418
H. Concluding Observations 422
Chapter XII, DOD Scientific Research Accomplishments and the Impact of Military Research on Science 423
A. Influence on the Formulation of the Government/Science Support Relationship 423
B. Reports of Scientific and Technical Findings 425
C. Arguments That DOD Has Stimulated the Growth of Certain Fields of Science 426
D. Claims of Second Order Benefits From Military Science and Technology 427
1. Commercial "Spinoff" 427
2. The Military As an Agent of Technological Change 428
3. The Military As a Technological Risk Taker 429
E. Questions About Military Research 430
F. Concluding Issues 431
Chapter XIII, Economic Impacts of Defense R&D 433
A. R&D and Economic Growth: Theories 434
1. Economic Effects 435
2. Productivity Effects 437
B. Industrial Policy 438
C. Innovation 438
D. Technology Transfer 442
E. Security Classification 445
F. Effects on Trained Personnel 446
G. Concluding Observations 447

## TABLES, CHARTS, AND FIGURES

Chapter III:

A. DOD Funded Research as a Percent of Total Federally Funded Research 35
B. Change in Status of University-Affiliated FFRDCs and Labs 1966 to 1975 56
C. DOD Funding of Social Sciences Research 57

Chapter IV:

A. RDT&E by Activity 68
B. RDT&E by R&D Category 70
C. Percent of Total Federal R&D That Goes to Defense R&D 71
D. DOD Science and Technology Trend, Percentage of DOD RDT&E 75
E. Defense RTD&E and Tech Base Funding in FY85 Constant Dollars 76
F. DOD Science and Technology Trend Current and Constant Dollars, Research (6.1) 78
G. DOD Science and Technology Trend, Research (6.1) Relative to Research, Development, Test, and Evaluation (RDT&E) 79
H. RDT&E by Performer 82
I. Performers of DOD Science and Technology 83
J. Research (6.1) Program Funding 85
K. SDI Funding to Universities 86
L1. Department of Defense Obligations for Research and Basic Research, by Field, Fiscal Years 1985, 1986, and 1987, estimated 87
L2. Department of Defense Funding for Basic Research by Discipline, FY83, FY84, FY85, and FY86 88
M1. Partial Organization of the Office of the Secretary of Defense 93

Page

Chapter IV—Continued

M2. Defense Acquisition Organization .......... 94
N. Organization of the Office of the Deputy Under Secretary of Defense for Research and Advanced Technology (1983) .......... 95
O. Army Research Management Structure .......... 96
P. Navy Research Management Structure .......... 98
Q. Air Force Office of Scientific Research .......... 100
R. DARPA Management Structure .......... 104

Chapter V:

Tables:

1. Percentage of Federal R&D Obligations to Colleges and Universities From DOD .......... 135
2. Percentage of Federal Basic Research Obligations to Colleges and Universities From DOD .......... 135
3. Federal Contract Research Centers Reported to the Subcommittee of the Committee on Appropriations, House of Representatives, May 1963 .......... 139
4. Federal Contract Research Centers Reported to the Subcommittee of the Committee on Appropriations, House of Representatives, 1964 .......... 141
5. DOD Support for Research and Development at Colleges and Universities by Character of Work (Current dollars) .......... 146
6. DOD Support for Research and Development at Colleges and Universities by Character of Work (Constant dollars) .......... 147
7. Department of Defense Funding for University Basic (6.1) Research, Fiscal Years 1974–86 .......... 154
8. DOD Support of Research at Colleges and Universities by Fields of Science .......... 164

Figures:

1. DOD Obligations for Research at FFRDCs Administered by Colleges and Universities by Character of Work .......... 143
2. DOD Support of R&D at Colleges and Universities (Billions of Dollars) .......... 144
3. DOD Support of R&D at Colleges and Universities (Millions of 1972 Dollars) .......... 149
4. DOD Support of Research and Development at Colleges and Universities (Table) .......... 150
5. DOD Support of R&D at Colleges and Universities (Graph) .......... 157
6. Percentages of Total DOD Support for Basic Research Performed at Colleges and Universities .......... 158
7. DOD Support of Research at Colleges and Universities by Fields of Science (Table) .......... 163
8. DOD Support of Research at Universities by Field of Science (Graph) .......... 165

Chapter VI:

Figures:

1. Total DOD Laboratory 6.1 and 6.2 Funding in Constant Dollars, FY73–FY83 .......... 182
2. Statistical Information on Department of Defense Laboratories, FY73–FY83 .......... 183
3. Army, Navy, Air Force Laboratory 6.1 and 6.2 Funding in Constant Dollars FY73–FY83 .......... 184

Chapter VII:

Tables:

1. DOD Share of All Federal Obligations of R&D Performed by Industry .......... 281
2. Composition of DOD Funds for RDT&E Performed by Industry .......... 286
3. DOD Share of All Federal Obligations for R&D Performed by Industry (Excludes FFRDC's) .......... 286
4. Patterns of RDT&E Performance by Military Services and Agency 287
5. Shares of Components of Technology Base Performed in Industry.. 291
6. Trends in Scope of Major Prime RDT&E Contracts .......... 293
7. Trends in Numbers of Major Prime RDT&E Contracts .......... 294
8. Top Ten RDT&E Prime Contractors .......... 296
9. Major RDT&E Contractor Activities by Area of Application .......... 296
10. Top 10 DOD Prime Procurement .......... 297
11. Number of Top 100 DOD Prime Contractors Active in Each Procurement Category .......... 297

Page
Chapter VII—Continued
Tables—Continued
12. Distribution of RDT&E Contract Awards by Budget Category and Area of Application ..... 298
13. Composition of DOD RDT&E by Purpose of Budget Activity ..... 299
14. Composition of DOD RDT&E by Budget Category ..... 299
15. Magnitude of DOD SBIR Program ..... 312
16. DOD SBIR Proposals and Awards ..... 313
Figures:
1. DOD Share of Industrial Basic Research Funds ..... 282
2. DOD Share of All Industrial R&D Funds ..... 283
3. Obligations for DOD Technology Base (To Industrial Performers) ..... 289
4. Industrial Performer Shares of Technology Base ..... 290
Chapter VIII:
Tables:
1. Statistics Relating to IR&D, B&P, and OTE for Major Defense Contractors, 1964-1974 ..... 327
2. Statistics Relating to IR&D and B&P, 1974-1984 ..... 328
3. Comparison of IR&D Reimbursement Over the Last Two Decades ..... 329
4. DOD Shares of Allocated Costs ..... 331
5. Statistics Related to NASA IR&S and B&P, 1963-1973 ..... 345
6. Statistics Related to NASA IR&S and B&P, 1974-1985 ..... 346
Chapter IX:
Figure:
1. Foreign Doctoral Students in Emerging Engineering Areas: 1984 ..... 367

# CHAPTER I

## INTRODUCTION AND PURPOSE OF THE STUDY

This report was prepared by the Congressional Research Service in response to a request of the Task Force on Science Policy of the House Committee on Science and Technology, for a "comprehensive study of the role of the Department of Defense in providing support for scientific research." The study examines historical, organizational, financial, and policy questions about military research, exclusive of development, test and evaluation. Also, some attention is given to the balance between total military and civilian research and development and to implications for the economy of defense research and development. The Task Force asked that the study focus specifically on issues "* * * relevant to our understanding and evaluation of the role which DOD funding plays in the over-all research enterprise." Specifically the Task Force sought, and this study seeks to provide, information on the following issues:

(a) A historical perspective for the period since 1945.

(b) The role played by the DOD laboratory structure in the conduct and support of research.

(c) The similarities and differences in funding mechanisms used by the DOD in support of research in comparison with other agencies.

(d) DOD's policies for the support of basic and applied research in universities * * * [and the issue of training of scientific and technical personnel].

(e) The attitudes of university faculty and administrators toward national security-related research in general.

(f) The use of advisory committees.

(g) The policies and practices for DOD's support of research in industry including the extent and results of independent research and development programs.

(h) The changing impacts on research and on the economy of DOD support of R&D.

The study contains thirteen chapters which were separately written and organized to respond to the questions raised by the Task Force. The chapters were prepared independently by CRS analysts. Because data from different sources were used in each chapter, data are internally consistent within each chapter, but it should not be assumed that data are comparable between chapters. Most of the data and information conveyed are current through the early part of 1986.

Genevieve J. Knezo, Specialist in Science and Technology, coordinated preparation of Chapter II, the "Summary and Overview of Policy Issues Raised in the Study," and also served as project coordinator. She also prepared Chapter III, "Department of Defense Research in Historical Context," Chapter IV, "Military Research Funding Trends and Processes," Chapter IX, "The Impact of DOD Research Policies on U.S. Scientific and Technical Personnel," Chapter XI, "The Scientific Advisory System of the Department of Defense." and Chapter XII, "DOD Scientific Research Accomplishments and the Impact of Military Research on Science."

Michael E. Davey, Analyst in Science and Technology, wrote Chapter V, "Overview of DOD Support for Research at Colleges and Universities," and co-authored, with staff from the CRS Government Division, Chapter X, "DOD Research Performed in Universities and National Security Controls."

Chapter VI on "The Role Played by the DOD Laboratory Structure in the Conduct and Support of Research" and Chapter XIII on "Economic Impacts of DOD R&D," were prepared by Wendy H. Schacht, Specialist in Science and Technology.

Joan D. Winston, formerly Senior Research Assistant, and Christopher T. Hill, Senior Specialist in Science and Technology, prepared Chapter VII on "Department of Defense Support of RDT&E in Industry," and Chapter VIII, "DOD Support of Independent Research and Development in Industry: Issues and Implications for Federal Support of Civilian R&D."

The study was reviewed by the research group, and by other CRS staff, including: William Boesman, Specialist in Science and Technology; Jane Bortnick, Assistant Chief, Science Policy Research Division; Richard Rowberg, Chief, Science Policy Research Division; and by staff of the Foreign Affairs and National Defense Division.

# CHAPTER II

# SUMMARY AND OVERVIEW OF POLICY ISSUES RAISED IN THE STUDY*

This chapter summarizes the separate parts in the study and the various options for congressional attention or further examination that were developed in each chapter.

## A. Definitions

This study focuses primarily on Department of Defense (DOD) research funding and within that category on basic research funding. As elaborated upon in Chapter IV, DOD uses the budget category of 6.1, to report basic research funding. The dollar amount reported by the Department of Defense for this category is about the same as the dollar amount for DOD basic research reported in National Science Foundation (NSF) prepared documents on Federal research and development (R&D) funding.

DOD research funding, called "technology base" in DOD terminology, is composed of budget categories 6.1 and 6.2. The budget category 6.2 refers to exploratory development and is approximately equivalent in dollars to the amount reported by the NSF in the category of DOD applied research. Funding for the categories 6.1 and 6.2 is about equivalent to that reported under the NSF categories of basic and applied research respectively, which comprise the NSF category of "research" for DOD.

Total funding for the DOD budget category of research, development, test and evaluation (RDT&E) is analogous to the amount the National Science Foundation classifies as research and development (R&D) supported by the Defense Department. In this report the types of data and sources used are identified when necessary for clarity.

## B. History

Although historical perspective is a component of most of the chapters, chapter III concentrates on history. It describes the political and military events which have affected the conduct and organization of Department of Defense research, the changing organization of DOD research, and how DOD precedents in research funding procedures and expectations have influenced the Federal organization and practices for funding civilian research. Historical events affecting the support of DOD development, test, and evaluation activities, generally called "development" in this report, are referenced when necessary, to clarify the discussions of research activities. However, the focus of the history is on research-related events.

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### 1. IMPACT OF MILITARY RESEARCH ON CIVILIAN GOVERNMENT-SCIENCE RELATIONSHIPS

Military events and activities have long influenced the direction and organization of the science/government relationship, including civilian science. Historically, the most persuasive argument for Federal support for many kinds of science and technology has been military necessity. The development of civilian science advisory mechanisms and support programs has been closely intertwined with military research and development events. The success of World War II military research motivated efforts to maintain in the civilian sector many patterns of the military's scientific research support relationships with universities and industry that had begun during World War II and shortly thereafter. One of the major effects of this legacy is seen in Federal support programs for individual investigator-initiated research programs.

### 2. HISTORICAL FACTORS SHAPING DOD ORGANIZATION FOR RESEARCH SUPPORT

Many crucial changes in support of both military and civilian science have been reactions to military-related events. This is illustrated in nineteenth century military funding of research in medicine, topography, and natural and physical sciences (motivated in part by military programs for Westward expansion). In the 20th century, security-related events, such as the national concern about the comparative quality of U.S./U.S.S.R. science and technology following the launch of Sputnik, resulted in significant expansion of civilian science and technology programs. These include increases in science education programs in NSF, increases in most Federal agencies' research budgets, creation of the National Aeronautics and Space Administration (NASA), passage of the National Defense Education Act, creation of the President's Science Advisory Committee, and establishment of the Office of Science and Technology).

Major changes in DOD's organization for research support also have followed crucial security events. Chapter III chronicles such changes as the creation of the Advanced Research Projects Agency (ARPA, the predecessor of the Defense Advanced Research Projects Agency (DARPA)), and the establishment of the Office of the Director of Defense Research and Engineering, created as part of the national reaction in the wake of the Sputnik launch.

From 1958 until 1977, military research was coordinated by the Office of the Director of Defense Research and Engineering. The status of the office was elevated in 1977 when an Under Secretary for Research and Engineering was established. As concerns began to escalate about the gaps between research and development activities and procurement activities, the office was terminated in 1986 and its functions were transferred to a new Director for Defense Research and Engineering that was created within the Office of Undersecretary for Acquisition.

*Policy issue*

Most recently the Office of Under Secretary of Research and Engineering was terminated and an office of the Director of Defense Research and Engineering, responsible to the Under Secretary for Acquisition was recreated. This has raised questions about whether RDT&E will be jeopardized or improved if affected by the traditions and policies governing defense procurement.

## C. Funding Trends and the Civilian/Military Balance for R&D

Chapter IV discusses military research funding trends. From the second World War until the establishment of large research support programs in civilian agencies in the early 1960s, the military provided, on average, 75 percent of Federal funds for research and development. This percentage decreased thereafter. Several other factors, in addition to the growth of civilian R&D, appear to have influenced the cutback in the percentage of federal R&D funds going to defense. Concerns about the consequences of a growing "military-industrial" complex, highlighted by President Dwight D. Eisenhower's warnings upon leaving office, may have contributed to the subsequent decreases in support for military R&D as part of total Federal support for R&D. Another factor was the increase in operational military expenditures for the American military presence in Indochina. The Government supported about equal amounts of funding for defense and civilian research and development from the mid-1960s to the early 1980s.

DOD obligations for RDT&E were about $15 billion in 1980. The amount of federally funded R&D that goes for defense work has been significantly increased—both in absolute dollars and in relation to civilian R&D funding—since 1981. For about the last five years the military has begun to absorb U.S. Federal science and technology resources at percentage levels comparable to levels in the years prior to the mid-1960s. The Congressional Budget Office projects a 38 percent increase in military R&D spending (in constant dollars) between 1985 and 1989, but an increase of only 7 percent, actually a decline in real dollars of 11 percent, for civilian R&D, from $13 billion to $13.9 billion, by 1989.

OMB estimates that defense related research and development obligations—funded by the Departments of Defense (DOD) and Energy (DOE)—will total about $39 billion for the fiscal year 1987, and will constitute about 70 percent of all funds of the Federal Government R&D obligations for fiscal year 1987. DOD funds about 90 percent of the total amount obligated for defense related R&D and DOE funds the remainder, the latter principally for nuclear weapons research. Defense related research and development spending represents about one-third of total national (public and private) spending for R&D and is about 10 percent of the annual outlays for all national defense purposes. DOD outlays for RDT&E for FY1987 are estimated to total about $35.5 billion, or some 64 percent of outlays estimated for Federal R&D.

It should be pointed out, however, that despite these increases, the proportion of Federal R&D that goes to defense today is still below the high levels in the 1950s and early 1960s, when over 80 percent of Federal R&D funding went to support defense related work. In terms of constant 1982 dollars, DOD's RDT&E funding during the decade of the 1970s averaged about 30 percent less than the average for the decade of the 1960s. In constant dollars, funding for DOD RDT&E in fiscal year 1987 has surpassed, by about $2 billion, the highest annual expenditure level reached in the early 1960s.

These trends raise questions, as they did in the past, about the balance between military and civilian funding. Questions remain about the Nation's priorities for R&D funding and about whether the DOD needs to expand its activities to strengthen the scientific and technical infrastructure from which it expects so much.

*Policy issues*

Some argue that there are many opportunity costs resulting from the pattern of increasing Federal R&D resources for military purposes. These costs may take the form of using resources—human, intellectual, and physical—that might otherwise go to civilian research and development and toward enhancing the U.S. competitive posture in world high-technology trade. On the other hand, previous cutbacks in defense R&D have fostered underutilization or underemployment of the Nation's human and intellectual resources. In addition, defense R&D may tend to create spin-offs to the civilian sector, and increase employment overall. Should there be additional inquiry into this issue?

According to testimony to the Science Policy Task Force, the pattern of increase for military R&D (about 20 percent between 1986 and 1987) may have reached the point of diminishing returns.[1] Has the rate of growth of the R&D system kept pace with the demand? What are the policy consequences of increased military funding for R&D?

The DOD is increasing its support of research in certain areas relevant to the military, including: computer science, mathematics, astronautics and aeronautics. At the same time, it is increasing support to universities for applied research and development work. Debates about classification, secrecy in science, and DOD-determined and -directed vs. undirected basic research on campus are becoming more widespread. Concurrently, other sources of civilian Federal support for same fields of university research are diminishing slightly.

*Policy issues*

Since civilian R&D funding is declining so much relative to military R&D, what steps, if any, should science policy decisionmakers take to ensure maintenance of a diversified science/manpower/education base in the United States? [2]

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[1] Testimony of James Schlesinger before the House Committee on Science and Technology, Mar. 25, 1985.

[2] U.S. Congressional Budget Office. Research and Development Funding in the Proposed Fiscal Year 1985 Budget. Special Study, Mar. 1984, pp. 416–25.

Is there sufficient awareness that "national R&D investment . . . [is] . . . a critical factor in the health of the civil economy and the strength of the military forces"? [3]

Do military and civilian agencies coordinate research funding programs and priorities adequately both at the working level and at the policy level?

Should efforts be made, especially in defense R&D to "encourage governmental and industrial R&D interaction with the Western, allied R&D community since the United States is no longer preeminent in many areas of technology"? [4]

### D. Are DOD Budgets for Basic Research Adequate?

The drop in funding for military R&D as a percentage of total Federal R&D funding that occurred in the mid-1960s was accompanied by a cutback in the percentage of the total RDT&E budget devoted to research, especially to basic research, and in the amount of military research conducted on university campuses. This section summarizes relevant issues from chapters IV and V.

Most of the recent increase for RDT&E funding has gone to development, or more properly to the DT&E spectrum of DOD RDT&E, rather than to research. The trend shows a decrease in funding for technology base work (6.1 and 6.2) as a percentage of total DOD obligational authority and of total DOD RDT&E funding. The percentage of total RDT&E that goes to technology base work has been declining steadily, from a high point of about 25 percent of the RDT&E budget in 1965 to about 9 percent of the RDT&E budget in 1987. In terms of 1987 constant dollars the technology base funding declined from about $5.5 billion in 1965 to about $3.5 billion in 1987. DOD estimates that technology base funding will constitute 8 percent of the RDT&E budget in FY 1989.

DOD was the largest supporter of basic research in the Federal Government until the mid-1960s and today is the third largest, with 13 percent of the total. Basic research (6.1) funding, requested at the level of $918 million for fiscal year 1988 accounts for about 2.1 percent of the RDT&E budget, a decrease from the higher percentage levels of the earlier years (averaging about 4.6 percent in the 1960s and about 3.6 percent in the 1970s).

Several factors contributed to this percentage decline. One was the expansion of such other Federal R&D agencies as the National Science Foundation, the National Institutes of Health and the National Aeronautics and Space Administration. The military reasons were the need to devote RDT&E resources to incremental weapons refinement for Southeast Asian field operations and development of major new technologies, which required more funding in the category of "development." Another was the passage of the Mansfield amendment and its successor, the less-restrictive and modified Mansfield amendment, which confined military support of research to that potentially relevant to a military mission. Negative societal reactions to the Vietnam War also affected military research, by limiting the conduct of many classified and non-classified projects on campuses and by curtailing the conduct of R&D in some university affiliated, federally funded R&D centers, which had been established during and after World War II to provide technical information and R&D in specific areas.

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[3] On this point see: R&D for National Strength. By CSIS Panel on Science and Technology, Washington, Center for Strategic and International Studies. 1983, p. 13.

[4] R&D for National Strength, op. cit, p 13.

A fundamental question is raised: What is the appropriate balance of support between funding for research and funding for development, test, and evaluation? Despite the fact that the military agencies constitute the largest Federal supporter of some kinds of research (some areas of engineering, electronics, psychology, mathematics and computer sciences), some critics assert that the Department of Defense may be underinvesting in critical areas of military-related research, with the possible consequence that Soviet military technology development might surpass U.S. developments in the future. Areas where the Soviets have been said by some and disputed by others to equal or to exceed American scientific or technological capability include: microelectronic materials, electro-optical sensing, submarine detection, seabased missile systems, some types of fighter aircraft, air to air missiles, cryogenics, explosives, oceanography, high pressure physics, controlled atomic fusion, conventional warhead technology (including chemical explosives), some types of materials processing, and some types of military-oriented, computer-applicable algorithms. Questions have also been raised about whether DOD funding for basic research, totaling almost $1 billion annually, is adequate given the long lead time required to conduct the research needed to develop the technology necessary to maintain national strength and security. Recommendations have been made to enlarge DOD's research support programs. For instance, Franklin A. Long, Cornell University, testified before the House Task Force on Science Policy that DOD should increase its support of basic research in order to generate new scientific knowledge which is not necessarily immediately related to the Pentagon's research mission needs. He and others also have warned that increases in DOD's research funding should not take place at the expense of support for non-military research funding. Announced efforts over the years by DOD research chiefs to allocate increased minimum percentages of the DOD budget to the support of basic research have not been implemented.

Opposed to these views are the arguments that DOD is spending adequate amounts on basic research; that other Federal agencies, not DOD, should support more "dual-use" (i.e., military and civilian) basic research; and that DOD has difficulty in "transitioning" basic research into prototype technologies.

### *Policy issues*

Should the Department of Defense and Congress take steps to increase or decrease support for military research? Should more or less funding be allocated especially to basic research? Are there particular deficiencies or excesses in the exploratory development category (6.2)?

Questions are being raised about the capability of the Nation's R&D structure (in universities, industry, and scientific and technical personnel) to cope with the demands being placed on it by massive increases in funding for DOD RDT&E. Should the DOD expand its activities to strengthen the scientific and technical infrastructure from which it expects so much? Or will the new infusions of support and demands for S&T output help enhance the Nation's R&D resources? Alternatively, is there a point of diminishing returns in U.S. scientific and technological capacity beyond which military investments in R&D are inefficient and ineffective?

## E. Performers of Military Research

Chapter IV provides information about overall funding trends for military research. Industry is the largest performer of total DOD RDT&E (estimated at 71.7 percent in fiscal year 1986), followed by intramural performers (DOD's own laboratories), universities, and Federal Contract Research Centers, which are federally funded R&D center (FFRDCs). Basic research (6.1) is supported primarily by the research offices of the three services, the Army Research Office, the Air Force Office of Scientific Research, the Office of Naval Research, and the Defense Advanced Research Projects Agency. Significant research efforts in industry are supported by the military laboratories. As shown in Chapter V, universities perform the bulk of DOD basic research (category 6.1) at 50 percent, followed by intramural performers, at 30 percent, and industry and FCRCs at 20 percent. (About 12 percent is performed by industry and about 8 percent by FCRCs. See Chapter VII for additional information.)

The Navy spends most of DOD's basic research funds, 38.7 percent in fiscal year 1986; followed by the Air Force, 28.6 percent; the Army, 25 percent; and the defense agencies, including the Defense Advanced Research Projects Agency (DARPA) and the Uniformed Services University of the Health Sciences at 7.7 percent. While the Navy has the largest research support program of the services, the Air Force spends more on total RDT&E.

Military laboratories and industry have always performed more applied research, as well as research in the 6.2 category, than have universities. This ratio of performers has not changed significantly in recent years.

*Policy issues*

What is the appropriate proportion of research that should be performed in-house vs. extramurally in industry or in universities. Vested interests may affect decisions in this arena.

## F. Should Links Be Improved Between Research Investment Choices and Military Needs?

The Defense Science Board has criticized the absence of effective" . . . linkage between [RDT&E] investment strategies and the requirements of future combat." Others have suggested that consideration be given to decentralizing decisionmaking for some research funding to allow for the support of new research opportunities and needs as they arise. (See Chapter IV.) Several related issues will be discussed next.

### 1. IS MORE ATTENTION REQUIRED TO SET RESEARCH AGENDAS AND TO COORDINATE FEDERAL RESEARCH FUNDING?

Recommendations have been made to set a goal of "10 percent opportunity reserve in the research and exploratory development accounts" to enable the Services to fund promising lines of research without centralized control by the Pentagon. A specific recommendation is to create "DARPA-like" research support structures for each of the military services. (See Chapter IV.)

In addition, suggestions have been made for more stability in research lines of effort pursued by the Pentagon. Questions were raised in Chapter IV about whether there is too much duplication in research between the services and between DOD and other Federal agencies. There are indications that some members of Congress consider these as unresolved policy issues. In addition, writers such as Claude Barfield, for instance, have recommended that—

> The Reagan Administration should commission a study by an independent, respected outside body of scientists—the National Academy of Sciences is the most likely candidate—of the implication of the reemergence of the Department of Defense . . . as the single most important Federal R&D agency.[5]

Among the issues he said warranted study were the following: whether the information generated by DOD-supported basic research support projects would be allowed free communication throughout the community, and whether DOD manpower needs would draw off the Nation's brightest talent into narrow scientific fields of military interest.

DOD fiscal year 1987 obligations for basic research support are about one third the size of the National Science Foundation basic research obligations. A National Science Foundation/Office of Science and Technology report raised the issue that as DOD begins to target more areas for priority research funding, "There will be an increased need for government-wide coordination of research support at the disciplinary or program office level, as well as more generally, and NSF may well be required to return to somewhat of a 'balance wheel' role as a Federal research support agency." [6] Because of the increase of support for defense R&D as contrasted to civilian R&D, some analysts recommend that attention be given to assessing the balance in Federal support between military and civilian work and between NSF and DOD in the support of research. In 1983 the DOD established a "DOD/National Science Foundation Coordinating Committee" to coordinate Federal research support programs in universities in such fields as computer facilities and computer research and teaching.[7]

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[5] Barfield, Claude E. Science Policy for Ford to Reagan. Washington, American Enterprise Institute for Public Policy Research. 1982, pp. 118–119.

[6] The Impact of Increases in Defense R&D Expenditures on the U.S. Research System. In U.S. National Science Foundation. Emerging Issues in Science and Technology, 1982. A Compendium of Working Papers for the National Science Foundation. Washington, U.S. Govt. Print. Off., 1982, p. 42.

[7] Young, Leo. The University Link. Defense 83. Feb. 1983: 6.

*Policy issues*

Should the work of the DOD/NSF Coordinating Committee be expanded to encompass more agencies and more fields of science, to, in effect, create a Federal coordinating committee for the support of Federal research in universities?

Should the Services cooperate more to ensure coordination and eliminate duplication among research efforts?

What roles should DOD play in determining Federal science policies and priorities?

Is interagency coordination, whether formal or informal, among the agencies adequate?

Is better coordination needed to ensure that the laboratories do not support excessive amounts of duplicate research?

Should more attention be given in setting military research agendas to couple research needs (both long-range and short-range) to direct military needs?

Should consideration be given to creating "DARPA-like" research support agencies for each of the services?

### 2. IMPACT OF DEFENSE RESEARCH SPENDING ON SCIENCE

While defense research can be judged primarily on the basis of its contribution to maintaining military preparedness and national security, military research has also had major effects on civilian science policy. This is exemplified by the precedents the military established in creating organizations and funding mechanisms for Federal support of civilian research and in forging relationships with the scientific community. Also, DOD basic research, which its sponsors claim is largely nonclassified, has resulted in many referred journal articles, and in the last decade, in the award to at least 20 Americans of Nobel prizes. In additional military R&D has resulted in numerous patents.

The Department of Defense is one of the largest Federal agency supporters of research in psychology (DOD supports 40 percent of total Federal support for psychology). It is the largest agency suporter of federally funded research in social psychology (at 68 percent of the total); mathematics and computer sciences (DOD supports 60 percent of all federally supported research in this area and it is the largest agency supporter of research in computer sciences and interdisciplinary projects in mathematics and computer sciences); and engineering (it supports 42 percent of the Federal total and it is the largest agency supporter in electrical and mechanical engineering, metallurgy and materials). (See chapters IV, V, and XII.)

In addition throughout its history, the U.S. defense structure has always supported new areas of cutting-edge science. Today DOD research support continues to shape significant patterns in the conduct of civilian research. The agencies which comprise the DOD together constitute the largest Federal supporter of cutting-edge science in certain fields of engineering and mathematics in U.S. universities. In addition, military policies for manpower training, revitalization of university instrumentation and facilities often appear to be harbingers of subsequent Federal policies for these areas.

*Policy issues*

Unresolved policy issues are:

Should the military support such large amounts of fundamental scientific research?

Has military research support enhanced certain fields of science more than others? Which ones? If so, should the National Science Foundation play a role in coordinating such research funding?

On the other hand is the military supporting adequate amounts of research at the "cutting-edge" of technology, or is most of this work being supported by the civilian sector? Particular concerns are: computers, super computers, artificial intelligence, and materials.

### 3. MULTI-YEAR FUNDING

The argument has been made that present defense R&D investment patterns "tie" or commit research dollars to costly alternatives, whose development and procurement outcomes will require the investment of greater sums, which effectively have to be committed now, thus mortgaging the future of defense research and development.

*Policy issue*

Do present research investment patterns "mortgage the future" of defense research dollars? If so, are policymakers willing to foreclose the selection of future research support alternatives now?

The President's Private Sector Survey on Cost Control (the Grace Commission), among others, recommended that more research and development be funded using multi-year funding mechanisms. Others argue that annual authorization and review are required for proper oversight.

*Policy issue*

Should more research and development be funded using multiyear funding mechanisms?

## G. Is Defense Technology Too Sophisticated?

There are continuing debates about the relative merits of the emphasis of research and development on "high-technology" vs. "low technology" weapons and systems. (See chapters IV and VII.) The argument has been made that U.S. military systems, technologies, and weapons are becoming too sophisticated and their maintenance and use require a level of technical expertise not possessed by most U.S. voluntary military personnel. The counter argument is often made that sophisticated high technologies are necessary to enable the United States to overcome the numerical superiority of Soviet conventional forces and the Soviet push to develop and use sophisticated new technologies.

*Policy issues*

Does a commitment to large amounts of "high-technology" research, in effect, put too much money in one area, so that our adversaries will come to know and anticipate our major defenses in advance?

Are today's military weapons too complex? Are too many weapons too "high-tech" and difficult to operate effectively and maintain in battlefield conditions? Are they too costly? How questionable is their effectiveness?

Does the focus on "high technology" research consume resources that might otherwise be used for research on other promising, but "low-technology" issues?

Does a focus on "high technology" research commit budget funding in advance to "high technology" areas that will continuously need to be updated, thereby consuming large amounts of research dollars?

Is the United States committing too many R&D resources to the development of technology and advanced hardware that will not necessarily enhance battlefield capabilities?

In contrast should the military devote more research resources to the improvement of conventional military technologies?

## H. RESEARCH PROCUREMENT AND THE EFFECT OF THE COMPETITION IN CONTRACTING ACT

It is pointed out in chapter IV and V that although some academic researchers object to military funding on philosophical grounds or because they object to doing classified research, many welcome military funding. One crucial factor is the need to conduct research in support of defending the Nation's interests. There are other considerations which make military research support partictularly attractive to some scientists. One reason is that military research proposal review and funding procedures usually are less burdensome and move to closure more quickly than civilian research funding procedures. In addition, the military tends to use internal peer reviewers and multi-year "cluster" funding more than many civilian agencies. Further, the military is often the only or major supporter of cutting-edge science in such crucial fields as electronics and computer sciences.

*Policy issues*

Are the military research procurement practices more effective and efficient than civilian practices? Should civilian agencies adopt some of the DOD practices? Or do DOD agencies have specific defense requirements which preclude more competition in scientific research awards and use these practices to ensure that work needed for national security purposes does indeed get done in a timely fashion?

Some DOD officials charge that recent actions to enhance the competitive basis of procurement possibly may have jeopardized the process of research funding and, as a consequence, that research procurement should be treated differently from procurement of other military goods and services. They also allege that requirements of the Competition in Contracting Act may promote the premature disclosure of research information.

*Policy issues*

Should the Competition in Contracting Act be revised to exempt military research funding in order to facilitate the procurement of research and shorten the time period from submission of research proposals to award of funds?

Should the concept of "competition of ideas" be used to satisfy the goal of requiring competition in contracting?

### I. THE ROLE OF DARPA

The Defense Advanced Research Projects Agency (DARPA) was created in 1958, following the launch of the Soviet "Sputnik," and in response to a belief that high level attention was needed to coordinate promising research. DARPA performs a corporate research function serving all branches of the services. Recently DARPA was given broader responsibilities to support prototype testing. This may be in response to criticisms that DARPA's research topics were too long-range and too far removed from the knowledge needs of the military services. In addition, the services have complained about the difficulties encountered in "transitioning" DARPA research knowledge into technologies the services can use. It was pointed out in Chapter IV that while some have criticized the remoteness of DARPA research support from battlefield missions, DARPA generally is praised for its successful "corporate research" support functions, its leadership in support of several areas of cutting-edge science, and the streamlined procedures it uses to fund research. Some allege that DARPA's new responsibilities detract from the original mission of DARPA to support "cutting-edge" research. The change in DARPA's functions has raised questions about whether this new emphasis will jeopardize its highly acclaimed and unique research practices and successful research relationships with academic performers. See also chapter VII.

*Policy issues*

Should the Congress maintain close oversight of the DARPA research agenda to determine whether its new responsibilities for development and prototype testing might unduly distort its research support functions?

Should more effort be made to ensure the transfer to the Services of findings generated by DARPA-supported research to deal with the criticisms raised about inefficiencies in the utilization of DARPA work?

### J. MILITARY RESEARCH AT THE NATION'S COLLEGES AND UNIVERSITIES

Particular attention is given in Chapter V to the military research presence on academic campuses. The topics covered include: the history of funding support, DOD support of university research infrastructure, educational programs, and support of research by fields of science. During the 1950s and early 1960s DOD was the largest Federal supporter of academic research, providing in 1958 41 percent of all Federal R&D funding to universities. Difficulties in DOD-university relations and the creation of other Federal support agencies reduced the DOD role, so that by 1975, universities received only about 8 percent of federally funded R&D from DOD. Military research spending on campuses has accelerated under the Reagan Administration. During the 1980s, the inception of the SDI program and growth in RDT&E funding increased DOD's research support role on campus, so that by 1985 military R&D funding increased to 16 percent of all Federal R&D funds received on campuses.

The largest component of DOD RDT&E funding to universities and university-affiliated FFRDC's is for development (D, T&E) activities, which comprise 48 percent of total funds awarded. Chapter V concludes "This is a recent phenomena that should be watched carefully, since development projects are often classified, thus restricting publication opportunities. Consequently, academic concern, focusing on how growing DOD development funding might detract from the broad mission of the university, is understandable."

There are continuing policy issues affecting DOD research activities at universities which may require additional attention. These include:

### 1. RAPIDITY OF FUNDING INCREASES

DOD is now the fastest growing Federal agency supporter of research on campuses due in large part to the increases made in the SDI program. Many researchers welcome such funding, especially since Federal civilian applied research support has decreased in recent years. However, some academic scientists, especially those opposed to the SDI, have chosen to boycott SDI funding. Others object to military support of classified research on campuses. The argument has been made that opposition to DOD-supported research on campuses might become less salient if Federal funding for non-military research were to increase.

*Policy issue*

> What impact will rapid increases in DOD support for research and development at universities have on the Nation's campuses?

### 2. IMPACT ON ACADEMIC RESEARCH PRIORITIES

DOD's support for basic research at colleges and universities is heavily concentrated in computers, mathematics, engineering, and materials research in order to meet priority military research targets dealing with such areas as very high speed integrated circuits, software development, and artificial intelligence. It has been suggested that such funding will displace researchers who might otherwise work on civilian science. On the other hand, DOD support of these fields may lead to the production of dual use technologies or knowledge which can easily be transferred from the military to the civilian sectors.

*Policy issues*

Today DOD research on campuses appears to be much more closely linked to specific technological needs than it was in the 1950s and 1960s. But this may not be true.

In what ways will rising DOD support of research at colleges and universities affect academic research priorities and the freedom to set priorities?

Should the DOD increase or decrease support for research at universities?

Should the DOD devote more or less support on campuses to research on arms control and international negotiations, and to other "alternatives to military approaches to security. . . ."?[8]

### 3. "SPINOFFS"

There are pros and cons to the argument that military research, especially at colleges and universities, generates civilian technological spinoffs. Although there is no evidence to prove it, it may be that most "spinoff" technology emanates from DOD development activities. Further, DOD development activities are by far the largest portion of the DOD RDT&E budget. NSF data show that about 40 percent of DOD support for R&D at universities is for development; that the military is the largest Federal supporter of development activities on campuses (including FFRDCs); and that DOD support for development on campuses exceeded DOD support for basic research by about $175 million in fiscal year 1985. Most of this work is classified, increasing ". . . concerns about universities' abilities to maintain an atmosphere of openness and to share the results of their work for potential commercial spinoffs."

*Policy issue*

To what extent does military research at colleges and universities contribute to civilian technological spinoffs?

### 4. EFFECTS OF BUDGETS ON CAMPUS RESEARCH

University observers have noted that DOD support for research on the Nation's campuses could be affected by congressional efforts to reduce the growing deficit. If DOD research funds were reduced, as they were in the late 1960s and early 1970s, long-range research would be vulnerable, as military research managers tend to shorten their time horizons when budgets are tight. Usually in-house research support programs are protected, while cuts, if necessary, are made to extramural research. Recently cuts were made in DARPA's programs and for DOD support of basic research. Additional cuts of this nature in university work could have severe consequences on research in such areas as artificial intelligence, software development, computer sciences, and materials research.

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[8] Long, Franklin A. Government Dollars for University Research. Bulletin of the Atomic Scientists, v. 42, Mar. 1986: 48.

*Policy issue*

To what extent and effect will changes in DOD research funding priorities affect its relationships with colleges and universities as well as research funding patterns?

### 5. DOD SUPPORT FOR ACADEMIC INFRASTRUCTURE

Military R&D now absorbs over 70 percent of the DOD RDT&E budget and constitutes over 16 percent of all Federal R&D funds to universities. During the period of growth in funding, DOD began to augment its programs to improve the quality of university equipment, and to fund instrumentation, fellowships, and faculty support. Nevertheless, questions have been raised about whether the DOD's growing research and development needs are straining the Nation's research and development infrastructure in universities, industry, and laboratories, and whether the Defense Department should expand its activities to support infrastructure. One recommendation is for the Pentagon to enlarge its support programs for university instrumentation. Others believe that DOD compensation to research facilities is ample to contribute to overhead and that DOD should not directly assume such responsibilities which are best left to civilian research funding.

*Policy issues*

Should the Pentagon increase programs to support university facilities and instrumentation?

Should DOD play a smaller or greater role in guiding Federal support programs and policies for science, and should it augment or decrease its programs to enhance university R&D capabilities?

### 6. UNIVERSITY/INDUSTRY RELATIONSHIPS

Recently the DOD revised its independent research and development (IR&D) policies to induce industries to work more cooperatively with universities to generate necessary research. (See Chapter VII.)

*Policy issue*

Are there other opportunities in the military R&D area to encourage industry to increase its involvement with the university community and to support academic research, cooperative R&D projects, equipment, and fellowships? [9]

## K. IMPLICATIONS OF THE STRATEGIC DEFENSE INITIATIVE PROGRAM

The rapid increase in funding for the SDI research program generally ($1.4 billion in fiscal year 1985, $2.75 billion in fiscal year 1986, and $3.21 billion in fiscal year 1987), and specifically to colleges and universities (about $77 million in fiscal year 1985, $152 million in fiscal year 1986, and $264 million in fiscal year 1987) has raised several concerns. SDI needs caused shifts in research funding from other service research programs to the SDI program. As a result, according to Dr. Edith Martin, former Under Secretary of Defense for Research and Engineering, this may affect the balance and mix of the Services' research programs:

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[9] R&D for National Strength, op. cit., p. 14.

> . . . [T]he Air Force science and technology program transferred $41 million to SDI in fiscal 1985 funds. As a result of these SDI funding decisions, the Air Force lost much of its directed energy program, the laser hardening program (including tactical), the electromagnetic gun program, and the development program in ultraviolet and long wavelength infrared surveillance technology. It is thus necessary to ensure that overall Air Force mission requirements to not suffer as a result of SDI.[10]

Questions have also been raised about the balance in research between the SDI program and conventional weapons programs. Additionally the SDI Innovative Science and Technology office (IST), which funds most of the "basic research for SDI at universities" has awarded long-term contracts to support several industry-university research consortia.[11]

*Policy issue*

Is there an adequate balance of support between other weapons research and SDI research?

### L. DOD RESEARCH PERFORMED IN UNIVERSITIES AND NATIONAL SECURITY CONTROLS

Chapter X provides an historical analysis from the World War I to the present of the impact of national security controls on research performed in universities and supported by the Federal Government.

After World War II, the Federal Government began to place peacetime restrictions on exports from the United States to certain countries for reasons of national security. Provisions of the Export Control Act and of the Atomic Energy Act of 1949 embody the Government's resolve to prevent the unauthorized dissemination of certain kinds of science and technology information.

The export restrictions were eased during the 1960s and the early 1970s during an era of increased trade and scientific cooperation between the United States and the Soviet Union and the Warsaw Pact nations. But tensions heightened during the last half of the 1970s; culminating in action after Soviet military incursions in Poland and Afghanistan, with the result that scientific and technological exchanges were curtailed. This tension became more pronounced during the Reagan Administration and "has resulted in a more vigorous enforcement of laws restricting the availability and communication of information or goods of possible value to a hostile nation, primarily the Soviet Union."

For the first time since the 1950s the Administration is using several national security-related legislative and executive authorities that had been allowed to languish. These activities have directly affected universities. Most academicians believe that the campus-based research should have one function, that is the advancement of knowledge. Many also insist that academic freedom should mean an environment free of Government controls on the sharing of research findings. DOD policy attempts to endorse the benefits of open publication and dissemination of basic research findings because these freedoms outweigh the detriments associated with preventing dissemination. However, DOD responsibilities to prevent the illegal transmission of certain kinds of scientific and technological information and to halt the Soviet acquisition of Western science and technology have led to recent Reagan Administration attempts to tighten controls on scientific and technological information. There is concern that Strategic Defense Initiative work may well eventually be classified. Also, some academics point to DOD's recent attempt to control which foreign students will have access to NSF supported supercomputers as a sign of growing DOD control of university-based research.

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[10] Managing Science and Technology for the Future, DS2003+, Aug./Sept. 1985: 52.

[11] Hartung, William and Rosy Nimrody. Star Wars: Pentagon Invades Academia. Council on Economic Priorities, Newsletter, Jan, 1986, pp. 3-4.

This chapter concludes by noting that even with relatively high levels of cooperation between the academic and national security communities, there are multiple tensions inherent in resolving policies involving fundamental issues such as: freedom of speech, academic freedom, health of the Nation's scientific establishment, potential technological spinoffs, and national security concerns.

*Policy issues*

Will academic freedom be compromised by increased DOD funding of academic R&D?

SDI research is fundamentally mission-oriented research and is likely to be classified despite current policies against classification. Will SDI research funding on campuses ultimately constitute a significant threat to academic freedom?

### M. SCIENTIFIC AND TECHNICAL PERSONNEL

Chapter IX deals with the issue of the effects of military R&D spending on U.S. scientific and technical personnel supply and demand. There is some evidence of potential problems in the supply of scientific and technical personnel to conduct military R&D. Exact figures about the draw exercised by military R&D needs on the technically trained workforce vary. Pentagon officials estimate that about 17 percent of the Nation's scientific and technical personnel engage in military-related work. Others place the figure at closer to 30 percent.[12] It has been estimated that R&D needed for a fully-funded SDI program would utilize noticeable percentages of scientific, especially physical sciences, personnel. Another personnel issue concerns the balance between civilian and military use of the Nation's scientific and technical personnel. There is evidence that our major economic competitors, who devote very little to military R&D, outperform the United States in terms of productivity and penetration of high technology markets abroad. In addition, some critics allege that one of the costs of increasing

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[12] Dumas, Lloyd L. University Research, Industrial Innovation, and the Pentagon. In Triman, John, ed. The Militarization of High Technology. Cambridge, Ballinger, 1984, p. 138.

R&D investments in defense work is impairment of the civilian infrastructure in transportation, highways, and other public works.

There is also evidence that demand for military R&D may deplete supplies of some kinds of scientific and technical workers in the short-run. This is particularly noticeable in the fields of computer sciences, aeronautical/astronautical engineering, and electrical/electronic engineering. However, the long-term effects of such demands are less clear, because normal market mechanisms, as well as DOD support and training programs, may act to augment supply.

It also should be pointed out that some military decisionmakers are concerned about the implications of the Soviet Union producing far more technically trained personnel than the United States. Questions also have been raised about the technological literacy of U.S. students overall and the quality of students entering the S&T training pipeline. In addition, trained scientists, technologists and engineers have been leaving universities and defense laboratories for more lucrative salaries in industry, including the defense industry. Historically, the military has initiated and continued to support educational and training programs to augment national supplies of scientists, engineers, and technicians. Currently the DOD is sponsoring several programs of this nature.

*Policy issues*

> The issue of supply and demand appears to require additional study, particularly of the extent of personnel shortages in specific fields and sectors in demand by both the military and civilian sectors of the economy.
>
> What detrimental effects on U.S. commercial and military research might occur because more than 50 percent of graduate level students in some areas are foreign nationals? Most of these students will not be able to do research for the U.S. defense system immediately after receipt of the Ph.D. because of security clearance requirements.
>
> Should efforts be made to increase salaries to "attract and retain qualified managers of military R&D and provide—through education, career development and other incentives—for a larger, more competent military staff of R&D personnel"? [13]
>
> Is it necessary to mount specific efforts to provide the level of industrial mobilization and personnel training required to satisfy the demands DOD is placing on industry? [14]
>
> Should DOD increase its efforts for personnel training or should other Federal agencies charged with supporting non-defense science and technology play greater roles to augment personnel supplies?

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[13] R&D for National Strength, op. cit., pp. 13-14.

[14] The Impacts of Increase in Defense R&D Expenditures on the U.S. Research System, 1983, op. cit., pp. 38-39.

## N. Improvements Needed in Defense Laboratories

The focus of Chapter VI is on issues concerning research performed in military laboratories. Other related issues are discussed in chapter IV.

There are 72 defense laboratories (35, Army; 23, Navy; and 14, Air Force). The Air Force and the Navy are the largest performers of laboratory RDT&E in terms of dollars obligated. The laboratories, in fiscal year 1987, are slated to perform about 25 percent of DOD's RDT&E, totaling about $9 billion. Military laboratories perform about 40 percent of basic and applied military research, with total funding amounting to about $1.4 billion in 1987, estimated. The performance of research typically comprises about 5–20 percent of the work of the laboratories. The laboratories' performance of 6.1 and 6.2 work has increased about 3 percent annually since the fiscal year 1976.

Data in chapter VI show that about 60 percent of the DOD's technology base activities (6.1 and 6.2) were performed or funded by the laboratories during the period fiscal year 1973 to fiscal year 1983. In addition to performing research laboratories may award contracts to extramural research performers, including industry, universities, and Federal contract research centers.

Most of the research the laboratories perform or support is applied. The laboratories undertook approximately four times as much 6.2 work as 6.1 basic research during the period 1972 to 1983. Laboratories also perform almost 30 percent of military basic research. Universities are the largest performer at about 50 to 55 percent annually. Most of the laboratories' work, however, falls within the development end of the R&D spectrum.

The laboratories conduct a diverse array of work, including research relating to underwater activities, the atmosphere, ship testing, the development of weather resistant clothing, refinement of electro-optical materials, ergonomics, the development of psychological testing profiles, and health. Their comparitive advantage as performers is that they do work on a continuous basis and often from an anticipatory or long-range perspective to serve a particular defense mission especially relevant to the services. Unlike universities, they are applications-oriented and they constitute an up-to-date and immediately available core of scientific and technical knowledge. In addition, it is easy to attach security classifications to their work.

In addition to research, the laboratories provide technical support and advisory services to the military. They advise the service's scientific offices on research needs and priorities, and in some cases, their staff help to peer review university research proposals.

### 1. ISSUES RELATING TO RESEARCH PRIORITIES, REVIEW, AND PERFORMANCE

A number of recent study commissions and other reports (Defense, Science Board, Packard Commission, etc.) have assessed the management practices, personnel policies, funding, and output of defense laboratories and made recommendations to improve their functioning. (See chapter VI for citations to relevant reports.) There have been criticisms about fragmentation and duplication, and criticisms that "too often the laboratories conduct R&D in areas of their expertise instead of in areas of the greatest military need."[15]

A recent study by the Center for Strategic and International Studies commented about the defense laboratories:

> They are subject to controls originally designed for operational military units, not for research scientists. They are at the end of long chains of command. They suffer from inflexible personnel policies that hamper mobility, reward, and accountability. Their researchers have difficulty maintaining contacts with other members of their disciplines, which is vital to innovation. The past successes of these laboratories are a tribute to the energy and perseverance of their best scientists. But too many are working against the odds.[16]

*Policy issues*

Numerous questions and recommendations have been made about improving the performance of the defense laboratories. Among them are:

"[The Office of the Under Secretary for Research and Engineering] USRDE, in conjunction with Service technology base managers, should designate lead laboratories in generic technology base areas within each Service. Candidate technology areas include: Space systems related technology (components, hardening, etc.); airborne radar technology; airborne electronic warfare technology; electron devices; and infrared technology."[17]

Should laboratory directors be given increased flexibility to allocate funds within their laboratories, rather than having to take specific detailed and precise directions from the top down? (Now discretionary funding in Navy labs constitutes about 2 percent of the budget, about 7 percent in Air Force laboratories, and about 10 percent in Army laboratories.)

As more of the laboratories' 6.1 and 6.2 budget is contracted out, more time and effort must go to contract monitoring, which may adversely diminish the capability of staff to do core in-house work. Should the consequences of these trends be examined?

"USDRE should direct that Services review DARPA programs over $30 million (total program costs—not annual) from the point of view of potential future military applications, operational needs and transition plans, and establish a mechanism to ensure coordination of system technology base program with the rest of the DOD technology base activity to ensure that multiple requirements are included in the development of the technology base investment strategy."[18]

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[15] McIntyre, John. Defense Science Board Reports on the Technology Base. Defense Science & Technology, May/June 1982, p. 63.

[16] R&D for National Strength, op. cit., p. 11.

[17] McIntyre, op. cit., p. 63.

[18] McIntyre, op. cit. p. 63.

Should consideration be given to "diversify the funding sources of defense research laboratories, to open up about 20 percent of their funding to other sources on a competitive basis with public and private sources, thus exposing them to the test of the marketplace in a way that should have positive effects throughout the research establishment." [19]

Should the military laboratories develop programs for interdisciplinary peer review of research results and should the work of defense laboratories be reviewed periodically ". . . to examine justification for their continued existence." [20]

The laboratories participate in sophisticated and systematic technology transfer activities. However, the question remains of whether there is sufficient interaction and exchange of ideas and information between laboratories within, and between, the Services and among the laboratories and industry to ensure optimum research production and technology transfer.

### 2. ISSUES RELATING TO LABORATORY PERSONNEL

Another issue relates to personnel levels and compensation for scientists and engineers in military laboratories. The number of slots available for scientific and technical personnel within the military laboratories has generally been declining. Rapid turnover of personnel at lower levels has been attributed to the lure of higher salaries in private industry compared to Government salaries. A variety of alternative personnel compensation schemes different from the civil service system are now being considered which would offer higher salaries for greater output. A test program was implemented at the Naval Weapons Center at China Lake and the Naval Oceans System Center in San Diego. Additional site experiments are being conducted. Subsequently the President proposed that the experiment be expanded to other parts of the Federal Government.

*Policy issues*

Since the laboratories perform such a substantial amount of technology base research, are they being adequately staffed and funded to meet current and projected needs?

Should there be an increase in the number of slots available for scientific and technical personnel?

Can pay scales for DOD military and civilian scientists and engineers be made more competitive with private industry?

Should alternative personnel compensation schemes be adopted at military laboratories?

Should the level of administrative support and central support services at laboratories be increased? [21]

Recently directives were instituted that require rotation in civilian and military technical directorships of the laboratories. This may be detrimental if institutional memory is desirable. But it may be beneficial from the standpoint of injecting new knowledge into the system. Will this new approach be effective? How much oversight should the Congress maintain of this issue?

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[19] R&D for National Strength, op. cit., p. 11.

[20] Ibid.

[21] Ibid.

### O. THE SCIENTIFIC ADVISORY SYSTEM OF THE DEPARTMENT OF DEFENSE

The Department of Defense has an elaborate scientific and technical advisory system, composed of private sector and governmental officials, to advise individual laboratories, military service chiefs, and the Office of the Secretary of Defense. This is described in chapter XI. At the laboratory level, scientists advise on technical matters. The Defense Science Board (DSB), which was created to advise the Secretary of Defense, has dealt with both specific and broad policy including such issues as scientific manpower, defense industrial preparedness, the quality of the "technology base," technology transfer policy, and the standardization of weapons systems in NATO. Each military service also has a scientific advisory mechanism organized similar to the Defense Science Board.

The President's Scientific Advisory Committee (PSAC), which advised the President from the late 1950s through the early 1970s, and the current White House Council on Science and Technology, which advises the Director of the Office of Science and Technology Policy, also have played crucial advisory roles on defense research and development issues.

This study did not attempt to provide an assessment of the utility of the work of the DSB and the related bodies. However, secondary literature and congressional reviews of the work of the Board tend to demonstrate that the advisory bodies render important advice on many issues. It appears that this advice is subject to the constraint that it will probably be used only if sought, and that the defense scientific advisory groups most usually react to problems rather than develop policy on an anticipatory basis.

These bodies tend to be a useful source of objective expert information because they are not involved in the immediate day-to-day details of decisionmaking. Yet their very comparative advantage may diminish their utility because the nongovernmental experts, who mostly comprise these groups, work for firms and universities that provide services to the military, and thus may be subject to conflicts-of-interest. Various congressional groups have examined this problem and the DOD says it has taken action to alleviate any problems of bias and conflict-of-interest.

### P. DOD SUPPORT OF RDT&E IN INDUSTRY

Chapter VII focuses on DOD support of RDT&E in industry. The latest data show that during the fiscal year 1987, an estimated $25 billion, or 70 percent of DOD's funds for RDT&E, will be performed by industry. This is the largest single R&D activity in the free world. It is larger, for example, than the total amount spent on research and development for all purposes and by all sources in such countries as West Germany, France, and the United Kingdom, and is nearly as large as the entire R&D effort of Japan. Most of this work is classified, with some classified not only in technical detail but even as to its existence. (The other performers of DOD RDT&E are: in-house laboratories, about 25 percent of the total; Federal contract research centers, about 2.5 percent of the total; and universities, about 2.5 percent of the total.)

The chapter focuses on industrial performance of military basic research and "technology base" research and development. DOD supports about five times more basic research (6.1) in universities than in industry, but supports half again as much technology base research in industry (about $1.1 billion in fiscal year 1987, estimated) as in universities ($.76 billion in fiscal year 1987, estimated). In contrast to DOD R&D performed in universities, most DOD R&D carried out in industry is interdisciplinary and at the development end of the continuum.

DOD historically has been the major Federal supporter of R&D performed in industry. In fiscal year 1985 DOD support for R&D in industry totaled about $19 billion, or about 87 percent of all Federal funds for R&D performed by industry. Chapter VII provides an historical perspective on the industrial performance of DOD RDT&E, especially since World War II.

It also describes four specific DOD industrial RDT&E programs which have the objective of promoting the development of fundamental scientific and technical knowledge relevant to military needs. Some of them are also intended to promote the entry into defense-related R&D of small firms and their associated new technologies, especially in computation and computer sciences. The four initiatives are: the Small Business Innovation Research Program (SBIR), the Manufacturing Technology Program (ManTech), the Strategic Computing Initiative (SCI), and the Very High Speed Integrated Circuits (VHSIC) Program. Each initiative has different goals and follows different styles of management and organization.

The Strategic Computing Initiative and the Very High Speed Integrated Circuit Programs are both intended to advance the state-of-the-art in technical capabilities underlying families of new technology. SCI is focused on artificial intelligence applications and advanced computing technologies, and VHSIC on high-speed, large-scale, temperature-resistant, radiation-hardened, silicon-based, integrated circuit microchips. ManTech is a program intended to assist contractors to improve the productivity and performance of the technologies they use to produce items for DOD under procurement contracts. SBIR is DOD's participation in a legislatively-mandated program under which all major Federal agencies supporting R&D must set aside a fixed portion of their research and development budgets for small firms.

Each of these programs involves quite different DOD management styles. Projects carried out under SBIR and ManTech are managed and administered at the program level within the Services (and in the Defense agencies in the case of SBIR). SCI is a DARPA initiative, which has as a major goal the transfer to the Services of SCI technologies embedded in hardware. This is intended to be accomplished primarily through close cooperation with the Services, in part, to help alleviate some of the hand-off (i.e. "technology transfer") problems DARPA has historically encountered. The management structure for the VHSIC program is innovative for DOD in that it is a DOD-wide cooperative effort managed in the Office of the Secretary of Defense, with explicit coordination among the Services.

*Policy issues*

Major issues for congressional consideration that flow from this chapter are listed below.

### 1. BALANCE OF PERFORMERS

Most DOD RDT&E is performed under contract to the private sector. A rebalancing may be needed to produce more innovative and cost-effective outcomes. Possible alternatives include greater dependence on in-house laboratories and more dependence on private sector R&D paid indirectly through the profit margins allowed on procurements from industry.

Do the current organization, management, and budget priorities associated with DOD support of industrial R&D yield the most appropriate range of new and more effective defense technologies?

### 2. TECHNOLOGICAL PRIORITIES

Current defense policy may sometimes result in paying greater prices for some weapons systems that have only marginally higher performance than second-best alternatives. Some of these systems also lack reliability and availability.

Does DOD pay too high a price for marginal increments in performance of specific items of defense technology, or might more "defense" be purchasable by focusing the same funds on larger numbers of reliable, but marginally less-advanced systems?

### 3. DECISIONMAKING FOR WEAPONS R&D

Does today's investment in research for sophisticated weapons commit future large downstream expenses? If true, should DOD improve its process for judging new opportunities and for terminating projects at intermediate stages of development?

Does the current process for defense technology development carry with it a near term commitment to procurements of resulting systems?

### 4. EFFECTIVE USE OF PERFORMERS

The fundamental issue is whether RDT&E funds are spent wisely and efficiently by DOD and its industrial contractors. Subissues include: the openness of DOD RDT&E contracting procedures to new entrants and new concepts, the balance of fundamental research versus systems development, the effectiveness of DOD oversight of contractor efforts, and the ways in which procurement procedures enhance or detract from incentives for contractor performance.

Are there alternatives to the essentially monopsonistic (one buyer) market, with a somewhat closed and self-perpetuating system of technology development leading to procurement that is reinforced by the Independent Research and Development reimbursement mechanism?

How might existing procurement and contracting incentives by modified to enhance the entry of new firms into the defense arena, to stimulate cost cutting, and to strengthen the performance of defense technologies?

Does the implicit use of the linear pipeline model of innovation (basic research generates new ideas, which are explored in applied research, which are converted into weapons, systems, and devices by development projects) inhibit the effectiveness of the technology development process for defense systems? Alternatively, would military technological innovation be enhanced if firms were to decentralize some technology development efforts and to use joint ventures, to acquire more new technology-based small firms, and to participate in cooperative R&D activities with other firms or universities?

### 5. SECURITY CLASSIFICATION

Does the extensive and growing use of formal security classification for defense-related R&D create unnecessary barriers to both defense technology development and the spin-off of defense technologies to the civilian sector?

Does the separation caused by classification inhibit serendipity in research? Should DOD seek more overlapping membership of outside scientific advisors on seemingly unrelated advisory panels? Can defense technologies be made more readily available more systematically to the civilian sector?

### 6. SPIN-OFF TO THE CIVILIAN SECTOR

There are questions about whether DOD technologies, in fact, have much potential for application, because they are designed for unique military functions, their cost/performance characteristics are inappropriate for civilian use, or in many areas civilian technologies are actually more advanced than that used by DOD. However, others believe DOD should take a more active role in promoting technology transfer to the civilian sector.

How might DOD better encourage spin-off of its scientific and engineering developments to the civilian arena in the service of commercial and public interests?

Should existing programs for technology transfer be expanded, including the Stevenson-Wydler Technology Innovation Act of 1980, its amendment, the Federal Technology Transfer Act of 1986, and the draft Executive Order 12591 issued to implement the 1986 act?

## Q. DOD SUPPORT FOR INDEPENDENT RESEARCH AND DEVELOPMENT IN INDUSTRY

The Department of Defense, the National Aeronautics and Space Administration, and several other agencies allow contractors to recover a portion of their Independent Research and Development (IR&D) expenditures as overhead payments on their cost-based procurement contracts. Approximately $2 billion of DOD reimbursements for Independent Research and Development (IR&D) were made to industrial contractors in the fiscal year 1984. This relatively large sum is not included in the total of federally supported expenditures for R&D provided by the National Science Foundation and by the Department of Defense; generally it is totaled in DOD purchasing and procurement accounts. Although it is small compared with DOD RDT&E procurement budgets, the total reimbursements to DOD contractors for IR&D are greater than the R&D budget of the National Science Foundation and of all but the largest R&D supporting agencies. Chapter VIII focuses on the issue of policies for DOD to reimburse industry for Independent Research and Development and examines the applicability of similar mechanisms to fund the costs of maintaining the research infrastructure at universities.

In comparison with RDT&E contracts, the IR&D mechanism, it is argued, tends to strengthen DOD's technical base of contractors, encourage more vigorous technical competition among contractors, provide DOD with a broader spectrum of technical concepts and products, and enable more timely responses to new technological breakthroughs or threats. Reimbursing IR&D costs also creates an incentive for contractors to spend more of their own funds on research and development than they might otherwise, and it offers advantages to DOD in comparison with direct procurement of research and development because it allows for greater flexibility and variety of R&D project selection.

Chapter VIII describes how contractors recover a portion of their IR&D costs via overhead on government contracts and presents an historical analysis of the data describing IR&D costs to DOD. The IR&D mechanism has been a topic of continuing controversy because the processes DOD uses to decide the amount of IR&D costs that can be recovered are complex and difficult to understand. IR&D reimbursements are not subject to detailed congressional oversight. Because of its costs, there are differing views about whether the IR&D mechanism is the most effective and fair way to support independent research and development for defense needs. Also, some critics say IR&D contributes to a continuation and escalation of the arms race.

The analysis includes a section on the use of IR&D in such civilian agencies as the National Aeronautics and Space Administration, the Atomic Energy Commission, and the Federal Aviation Administration.

A number of recurring policy issues about IR&D are summarized, including evaluation of the benefits of IR&D and consideration of alternative approaches to achieve the same objective. Studies and analyses by the General Accounting Office, the National Research Council, DOD, and outside experts, have not produced unequivocal demonstrations of the effectiveness or superiority of IR&D in comparison with other approaches to defense R&D funding. However, an ongoing study by the Rand Corporation for DOD, required under the 1986 DOD Appropriations Act, may offer some new insights into these issues.

Proposals were made during the late 1970s and early 1980s that a mechanism similar to IR&D be used by NSF, NIH, DOE, NASA, DOD and other agencies that fund university research to support certain indirect costs that universities face in maintaining the infrastructure (facilities, equipment, new faculty) of research and graduate education. The major university research supporting agencies have taken some actions in the last five years or so to address these needs using direct funding rather than indirect, IR&D type funding mechanisms. The policy options discussed in the chapter are: modification of OMB circular A-21 to include IR&D, and policies about bid and proposal costs. Congress may wish to consider the pros and cons of an IR&D approach to funding the maintenance of university research infrastructures.

## R. Impact of Defense Research Spending on Economic Growth and Competitiveness

The evidence is unclear about whether military research spending adversely affects or enhances U.S. economic growth and technological competitiveness. This issue is discussed in Chapter XIII and treated as well in Chapters IV, VIII, IX, and XII.

### 1. DEBATES ABOUT THE IMPACT OF MILITARY R&D ON THE ECONOMY

Military R&D funding now constitutes about 70 percent of the Federal R&D budget, up from about 50 percent in 1980. Federally funded military R&D now constitutes about 33 percent of the Nation's public and private R&D. At the same time that increases were being made in military R&D funding, the Nation's balance of trade in high-technology products was eroding:

> In 1980, the high-technology industries produced a trade surplus of $27 billion, but this surplus has declined in every year since. In 1985, the high-tech surplus shrunk to $4 billion, and the trends established in the first two quarters of this year make it likely that 1986 will produce the first full-year high-tech trade deficit since this category was first identified.[22]

R&D investment patterns and high-technology trade performance are not necessarily related. There is no unequivocal evidence about whether national investments in military R&D impair or add to the ability of U.S. high-technology firms to develop capacity to produce commercial products for competition with Japanese and other foreign producers. Some claim that spinoff from military research investments enhances the capacity of American firms to develop products salable in world markets. For instance, in chapters XII and XIII illustrations are given of claims that military research has stimulated the growth of science and technology in such areas as polymer chemistry, theoretical phsyics, aeronautics, solid state physics, computer-relevant electronics science, eletrical engineering, halide glass research, and materials research. Claims are made that military R&D has "spun-off" or generated the development of such commercial products as antibiotics, plastics, synthetic textiles, nuclear energy, commercial aircraft, and fiber optic communications.

Some observers have credited DOD with having the resources, ability, and willingness to take economic and technological risks that the civilian sector has avoided, which in the past gave the U.S. military and commercial sectors technological advantages over competitor nations, resulting in both political and economic benefits. Such fields, it is claimed, have included micro-electronics, which led to the development of the integrated circuit, and nickel-based superalloys, which facilitated the development of jet engines. Such risk-taking behavior is probably imbedded in the current proposal for DOD to provide support for Sematech, a commercial joint R&D and, possibly, production venture relating to semiconductors. Certain aspects of DOD support for super computers are placed in the same category.

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[22] Finian, William, Perry D. Quick and Karen M. Sandberg. The U.S. Trade Position in High Technology: 1980-1986. A Report Prepared for the Joint Economic Committee of the United States Congress. Oct. 1986. Quick, Finan & Associates, Inc., Washington, D.C., 1986, p. 2.

Others claim that the growing emphasis on military research in universities and on defense work in high technology firms causes overspecialization in skills and capabilities and allows our economic competitors to make gains abroad. Some analysts[23] claim that because military R&D is concentrated—in weapons, aerospace and electronics—it makes little potential contribution to the civilian economy. "One-third of the DOD's R&D budget goes to the electronics industry, but only 2.4% of national income is generated by that sector. In 1983, the DOD spent more for R&D on the B-1 bomber than the total research budget of the entire U.S. steel industry."[24]

### *Policy issues*

Is there an appropriate balance between support for civilian and military research as a component of the Federal budget?

Some observers assert that achievements in military technology rest on achievements in civilian science and that, consequently, the military has a responsibility to ensure a healthy overall U.S. science and technology infrastructure and environment. What is the Pentagon's responsibility to ensure the health of the U.S. public and private research base? Would conferring such a responsibility on DOD give it power and authority inappropriate in our political system?

How much does the U.S. economy and our national potential for enlarging international high technology markets benefit or suffer from our heavy emphasis on defense-related R&D?

How cost/effective are investments in military research with respect to generating civilian spinoff? What are the variations in cost-benefit ratios by fields of science and area of technology?

If it is correct that the military takes risks avoided by other Federal agencies and the commercial sector, are steps needed to make technological risk-taking behavior less costly in the non-military and non-government sectors?

## 2. IMPACTS OF DEFENSE R&D ON PRODUCTIVITY

It is suggested in Chapter XIII that the sheer magnitude of defense R&D may have negative impacts on the U.S. economy because it may slow down productivity growth and diverts resources from the civilian economy. It also has been claimed that large investments in military R&D crowd out private investment and displace resources from the civilian to the military sector. Such a transfer is alleged to be further skewed because the Federal Government is the largest buyer or a dedicated buyer of certain kinds of technologies produced by industry, and, therefore, because of the absence of competition, fosters lower rates of productivity. There is no unequivocal evidence which would demonstrate the veracity of these allegations. Some claim that military support of R&D has enhanced the U.S. productive capacity via advances in manufacturing technologies. This may not be correct and it appears to be an area which requires additional study.

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[23] See for instance the examples cited in: Boesman, William C. and Michael E. Davey. U.S. Civilian and Defense Research and Development Funding: Some Trends and Comparisons With Selected Industrialized Nations. Washington, Congressional Research Service, Library of Congress, Nov. 5, 1984. (Report No. 84-195 SPR).

[24] Military Research and the Economy: Burden or Benefit. The Defense Monitor, v. 14, No. 1, 1985, p. 2.

*Policy issues*

> What are the effects of defense R&D spending on U.S. productivity? Can this be ascertained by current methodologies?

### 3. TECHNOLOGY TRANSFER

In Chapter XIII the point is made that technology transfer from the military to the civilian sector is constrained to the extent that military technology is designed specifically for a military purpose and may therefore be overdesigned or too sophisticated for use in the commercial sector. The potential for technology transfer to the civilian sector may be further limited because experience demonstrates that the most profitable and marketable technological innovations and products are those whose origins are market-driven rather than technology-driven. Most military innovations appear to be technology-driven, (Chapter XIII). The military need to impose security classifications on most of the work done at the DT&E end of the RDT&E continuum also handicaps the ready transfer of technology to commercial firms. However, legislation and recent practices, embodied in the activities of the Federal Laboratory Consortium and the enactment of the Federal Technology Transfer Act, P.L. 99-502, attempt to counteract some of these inherent obstacles.

*Policy issues*

> Does military R&D spending constitute an "ad hoc industrial policy?" Is it true that it is inefficient to try to induce civilian industrial innovation and commercial product development via a secondary spinoff route? Despite less than encouraging results up to the present, is it a more efficient Federal support policy to provide direct investment for civilian technological development?
>
> Should the Government develop explicit technology innovation support policies rather than using military R&D policies secondarily as ad hoc and indirect inducements for technological innovation?

### 4. GEOGRAPHIC CONCENTRATION AND ECONOMIC EFFECTS OF MILITARY R&D SPENDING

According to an economic study, the bulk of federally funded defense research and development is concentrated in a relatively small number of firms, areas, and schools. These patterns appear to have negative consequences for employment and improvement of the scientific capability in less utilized areas and suggest certain policy questions.[25] Specifically, DOD industrially performed RDT&E tended to be concentrated so that about 76 percent of such funds were awarded to firms in ten States (California, Massachusetts, Missouri, Florida, Washington, New York, Maryland, Kansas, Virginia, and Texas) having only about 41 percent of the population, as of 1980. Further, about 55 percent of all DOD intramural (that is, laboratory) R&D occured in only five States (California, Maryland, Ohio, Virginia, and New Jersey).

*Policy issues*

> Should military R&D funding be distributed on a more equitable geographic basis or is the proper criterion technological merit as specified by DOD's contracting procedures?
>
> Has this concentration of funding accelerated the decline of traditional "smokestack" industries? Is there a tendency for new high technology defense-related R&D firms not be located in "smokestack" industry states?
>
> In connection with DOD obligations to help maintain a base of industrial preparedness and readiness, does DOD have responsibilities to ensure a more equitable geographic distribution of its RDT&E awards?

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[25] Malecki, Edward J. Federal and Industrial R&D: Locational Structures, Economic Effects and Interrelationships. Norman, Department of Geography, University of Oklahoma, 1983, pp. 88–126.

# CHAPTER III

# DEPARTMENT OF DEFENSE RESEARCH IN HISTORICAL CONTEXT*

## A. INTRODUCTION

The objective of this chapter is to describe the major factors which have affected the course and conduct of Department of Defense-sponsored research, to identify critical historical events in the organization of Department of Defense research, and to identify aspects of military research which have affected the conduct and organization of civilian research. Events are described chronologically.

Military-supported research has been a crucial, if not determinant, part of the history of U.S. science policy for several reasons. Programs of military-sponsored research have affected the history and direction of American Government science and technology policy, both civilian and military. Defense research can be judged first on the merits of its contribution to maintaining military preparedness and national security. At the same time, major effects of military research on U.S. science policy are exemplified by the precedents the military established in creating organizations and funding mechanisms for Federal support of civilian research and in forging relationships with the scientific community. Also, DOD basic research, which its sponsors claim is largely nonclassified, has resulted in many refereed journal articles, and, in the last decade, in the award to at least 20 Americans of Nobel prizes for work done under DOD sponsorship in the fields of physical sciences, economics, and physiology and medicine. In addition, military research and development (R&D) overall has resulted in numerous patents.[1]

The relationship between the Federal Government and science was developed slowly and reluctantly, and largely as a sequel to military-related R&D activity. According to the National Science Board, "Because of the omission of explicit Constitutional authority for Government support, Congress often rejected proposals for Government involvement in science."[2] As a result, Federal Govern-

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*Prepared by Genevieve J. Knezo, Specialist in Science and Technology, Science Policy Research Division.

[1] Gamota George. Why Basic Research in DOD? Proceedings of an AAAS Symposium on Jan. 8, 1980: How Much Does the Defense Dept. Advance Science? Washington, Naval Researh Laboratory. NRL Rept. 8426, 1980, p. 2. For additional information about Nobel-prize awards, see U.S. Congress. House. Committee on Science and Technology. Science Policy Study Background Rept. no. 3. The Nobel-Prize Awards in Science as a Measure of National Strength in Science. Report prepared by the Congressional Research Service, Library of Congress. Transmitted to the Task Force on Science Policy. 99th Cong., 2nd Sess. Washington, U.S. Govt. Print. Off., Sept. 1986, 192 p. (Committee print.) Prepared by Christopher T. Hill and Joan D. Winston.

[2] The Mission Agencies: Comparative Analysis and Historical Trends. In U.S. National Science Board. National Science Foundation. Basic Research in the Mission Agencies; Agency Perspec-

Continued

ment scientific research was often supported indirectly. Most proposals for "scientific research" even in the late 19th century, were "passed only if they were attached to appropriations bills as riders,"[3] or as part of a military program, or in reaction to a threat to U.S. security. Such associated events have included wartime R&D, or the launching of the Soviet Sputnik satellite, which helped to revitalize Federal organization and support for science. Although the Government gradually began to support scientific research on its own merits, Dr. Jeffrey Stine reports that "National security was a major driving force behind U.S. science policy in the late 1940s and 1950s, fueled in large measure by the Cold War and the Korean War."[4] Later, the arms race, the space race, and the drive for national prestige wielded large influences. In addition, the impetus to create a civilian structure to support research and development was spurred largely by military related events. Harvey Brooks, a renowned science policy scholar has commented on this point:

> Throughout American history the impact of military motivations on the development of science and scientific institutions has been strong. The greatest periods of scientific development have often tended to follow military crises during which new scientific institutions were created. These war-generated institutions subsequently were turned towards the fostering and development of fundamental science. The American public has shown its greatest willingness to support science on its own terms when it could be related to national political prestige.[5]

For several years after large-scale Federal support for science began, "Military agencies funded about 70 percent of the total Federal expenditures for research and development during the early 1950s, thus minimizing the overall impact of the NSF. The National Science Foundation was created in 1950 to provide Government support in all research areas primarily to university scientists. National security remained the principal rationale for the support of basic research throughout his period, even for the NSF."[6] Calculations using OMB figures show that the percentage of total Federal R&D funded by defense agencies was even higher than 70 percent. During the ten-year period from 1940 to 1959 the share of Federal research and development funded by the military averaged 81 percent.[7]

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tives on the Conduct and Support of Basic Research. Washington, U.S. Govt. Print. Off., 1978, p. 323. Much of the NSB historical analysis is based on Dupree, A. Hunter. Science in the Federal Government. Cambridge, Belknap, 1957, passim.

[3] National Science Board, Ibid., p. 323, citing Dupree, Ibid., p. 291.

[4] U.S. Congress. House. Committee on Science and Technology. Science Policy Study Background Rept., No. 1, A History of Science Policy in the United States, 1940-1985. Report prepared for the Task Force on Science Policy. 99th Cong., 2nd Sess. Washington, U.S. Govt. Print. Off., Sept. 1986. 120 p. (Committee Print.) Prepared by Jeffrey K. Stine. See p. 38.

[5] Brooks, Harvey. Impact of the Defense Establishment on Science and Education. In U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research, and Development. National Science Policy. H.Con. Res. 666. Hearings, 91st Cong., 2nd Sess. July, Aug., and Sept. 1970. Washington, U.S. Govt. Print. Off., 1970, p. 931-931.

[6] A History of Science Policy in the United States, 1940-1985, op. cit., p. 38.

[7] Table 10.1 Summary of Outlays for the Conduct of Research and Development: 1949-1987. Office of Management and Budget. Historical Tables. Budget of the United States Government. Fiscal Year 1987. Washington, U.S. Govt. Print. Off. 1986.

Early in its history the Department funded over half of all federally-funded research. This decreased to about one-third in the 1960s, and now is about one-fifth. DOD funds a larger percentage of total Federal research and development, for instance DOD funded 80 percent of Federal R&D in 1960 and 72 percent of Federal R&D in 1988, estimated. See the following table regarding DOD research trends.

TABLE III.A.—DOD FUNDED RESEARCH AS A PERCENT OF TOTAL FEDERALY FUNDED RESEARCH [a]

[Dollars in millions]

| | Percent | Total federally funded research | DOD-funded research |
|---|---|---|---|
| Fiscal year | | | |
| 1956 | 56.6 | $852 | $482 |
| 1957 | 48.1 | | |
| 1958 | 45.3 | | |
| 1959 | 37.2 | | |
| 1960 | 44.3 | | |
| 1961 | 44.7 | | |
| 1962 | 40.1 | | |
| 1963 | 39.7 | | |
| 1964 | 37.5 | | |
| 1965 | 36.1 | | |
| 1966 | 35.1 | 5,271 | 1,849 |
| 1967 | 34.3 | 4,631 | 1,591 |
| 1968 | 32.9 | 4,781 | 1,577 |
| 1969 | 30.3 | 4,645 | 1,912 |
| 1970 | 27.1 | 4,901 | 1,330 |
| 1971 | 25.6 | 5,123 | 1,309 |
| 1972 | 27.1 | 5,548 | 1,505 |
| 1973 | 25.7 | 5,581 | 1,436 |
| 1974 | 23.2 | 6,175 | 1,434 |
| 1975 | 21.3 | 6,730 | 1,431 |
| 1976 | 20.0 | 7,619 | 1,527 |
| 1977 | 20.1 | 8,514 | 1,716 |
| 1978 | 18.9 | 9,607 | 1,824 |
| 1979 | 19.1 | 10,535 | 2,014 |
| 1980 | 19.5 | 11,507 | 2,262 |
| 1981 | 21.3 | 12,213 | 2,601 |
| 1982 | 22.6 | 13,022 | 2,953 |
| 1983 | 22.6 | 14,254 | 3,223 |
| 1984 | 20.3 | 14,979 | 3,049 |
| 1985 | 19.2 | 16,130 | 3,168 |
| 1986 | 22.2 | 16,455 | 3,359 |

[a] Calculated using National Science Foundation data. Sources include Federal Funds for Research and Development, Fiscal Years 1967 to 1986 and Federal Funds for Research and Development and Other Scientific Activities, Fiscal Years 1968, 1969, and 1970.

Throughout its history, the U.S. defense structure has always supported new areas of cutting-edge science. Today DOD research support continues to shape significant patterns in the conduct of civilian research. The agencies which comprise the DOD together constitute the largest Federal supporter of cutting-edge science in certain fields of engineering and mathemathics in U.S. universities. In addition, military policies for manpower training, revitalization of university instrumentation and facilities often appear to be harbingers of subsequent Federal policies for these areas.

Many examples can be cited in justification of these statements. For instance, it has often been noted that "the first Government-sponsored research program was the 1804 Lewis and Clark expedition funded by the Army to open the West to American settlement." [9] Other early examples of science in the military are evidenced by:

- —creation of a Corps of Engineers and the West Point Military Academy with officers trained in mathematics and astronomy for military and civilian applications as surveyors and topographers, and in hydraulics,[10]
- —research and development on preventive measures by the Army Medical Department during the Civil War and the late 19th century to control yellow fever, typhoid, and hookworm,[11]
- —communications, telegraph, photographic, and meterological work by the Signal Corps (called the Signal Service) during the Civil War,[12]
- —the Navy's four year long U.S. Exploring Expedition, which commenced in 1836, a worldwide survey and charting expedition involving hydrography, mapping, magnetic and astronomical observations, and studies in ethnology, anthropology, zoology, geology, meteorology, and botany,[13]
- —creation of the Naval Observatory in the mid-1800s, which is still charged with determining time for the Nation,[14]
- —the Navy's development of steam propelled ships during the Civil War,[15]
- —research by A. A. Michelson at the Naval Academy "on the velocity of light which eventually made him the first American Nobel Laureate in science." [16]

### B. MILITARY RESEARCH DURING WORLD WAR I AND WORLD WAR II

Despite these aforementioned scientific achievements and the creation of several military arsenals and laboratories, the U.S. military services appear to have lacked both a large and accomplished in-house R&D capability and a workable relationship with the civilian scientific community during the brief U.S. participation in World War I.[17] According to Dr. Harvey Brooks, this may not have been all that important because science and technology were not crucial determinants of the outcome:

> World War I was essentially a production war. The problems were for the most part those of improvement and adaptation of existing weapons and of organizing technical resources for war on an unprecedented scale. . . . The course of World War I was not decisively affected by con-

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[9] Suttle, Jimmie R. Basic Research From Lewis and Clark to Laser Physics. Defense 82, June 1982: 27; and Basic Research Program, 1984, op. cit., p. 4.

[10] National Science Board, op. cit., p. 325.

[11] Ibid., p. 326.

[12] Ibid., p. 326–327.

[13] Ibid., p. 329.

[14] For additional information on the history of the Naval Observatory, see Brooks, op. cit., p. 933.

[15] National Science Board, op. cit., p. 330.

[16] Ibid., p. 330.

[17] See U.S. Congress. House. Committee on Science and Technology. Task Force of Science Policy. Science Policy Study. Background Study No. 1. A History of Science Policy in the United States, 1940–1985. Washington, U.S. Govt. Print. Off., 1986, p. 15.

temporary technology, though it drew heavily on the accumulated knowledge and skill of the recent past.[18]

World War II depended far more on science and technology, and, as Brooks noted, ". . . many of the advances of World War II were generated initially in the laboratory and their military application evolved as strategy and technology were developed in tandem." [19] Some of the deficiencies in scientific advisory mechanisms and laboratory research capabilities that appear to have existed during World War I were rectified during the two decades after the war, so, that by World War II, the base of performers of military R&D was augmented by an enlarged in-house capability and by the development of research sponsorship relationships with industry and university researchers. The military also made a deliberate decision during World War II not to commission civilian scientists in order to leave them with "sufficient independent judgment." [20] In practice this led to the creation of effective working relationships and procurement patterns with civilian scientists. That helped the Nation to mobilize science for defense purposes in the Manhattan project, which developed the atomic bomb that was used to end the Pacific war, and in such other crucial areas as health, communications, radar, combat aircraft and transportation.

## C. AN OVERVIEW OF THE EVOLUTION OF THE ORGANIZATION OF MILITARY RESEARCH AND ITS IMPACTS ON CIVILIAN SCIENCE/GOVERNMENT RELATIONSHIPS

This section deals with the impacts of military research practices on the formulation of civilian research funding mechanisms and institutions.

### 1. FUNDING MECHANISMS

Federal civilian structures to govern and fund intramural and extramural research and development and to advise the Government on policies to use science and technology have important military antecedents. A major example is the creation of the National Academy of Sciences and its research arm, the National Research Council:

> During the Civil War, the Navy established a Permanent Commission which would answer the "questions of science and art upon which the Department may require information." The commissioners and three other scientists recommended creation of the National Academy of Sciences (NAS), which was incorporated in 1863. . . . In the course of World War I, the National Research Council was created as a working arm of the NAS. The Council was highly effective during the war. . . .[21]

Prior to U.S. entry in World War II, scientists concerned about the poor state of U.S. preparedness, proposed measures to improve coordination, mobilization[22] and linkage with the White House. President Franklin D. Roosevelt, by executive order, created a National Defense Research Committee (NDRC) to mobilize civilian research and scientific manpower for the wartime effort. Its charter was limited to conducting research on new military devices.[23]

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[18] Brooks, op. cit., 936.

[19] Brooks, op. cit., p. 936.

[20] Brooks, op. cit., p. 937.

[21] Basic Research in the Mission Agencies, op. cit., p. 323.

Brooks has described the importance of the R&D contract mechanism developed by NRDC and its legacy for Federal science policy:

> At the outset it determined not to build or operate laboratories of its own, but instead to develop contracts with universities and industrial firms, selecting the contractor best qualified for the job without reference to geographical or other political considerations. The research and development contract was really a new social invention, an open ended device using the legal form of procurement but without any clear specification of the end product. The principle of payment of full costs, including indirect or overhead expenses was fully recognized for the first time. The contract device permitted scientists, especially university scientists, to work on military problems within an organizational environment in which they were confortable, with colleagues whom they trusted and bosses whom they knew and respected.[24]

"The weakness of the NDRC," according to Brooks, "lay in the lack of a mechanism for transition from laboratory weapons to the battlefield and for coordination of its research with that carried on in military laboratories and the [National Advisory Committee for Aeronautics] NACA."[25]

Subsequently the NDRC was replaced when President Roosevelt created the Office of Scientific Research and Development (OSRD) in 1941. OSRD was placed within the Office of Emergency Management with direct access to the President. It directed most military R&D until the end of the war, and, according to Stine, established the basis of subsequent expectations about appropriate contract relationships between civilian scientists and government:

> . . . [T]he OSRD attempted to avoid disrupting the existing scientific structure. Reliance was placed on management and coordination, and research projects already undertaken by the Army and Navy were left in place. Supporting and expanding the existing system was seen as the quickest and most fruitful approach to mobilizing science and engineering for the war effort. Civilian scientists and engineers did not, therefore, don military uniforms as they had done during World War I. There was less emphasis placed on establishing new Government laboratories than there was during World War I, although some were created for the top-secret Manhattan Project. These laboratories were not operated by OSRD, however. The emphasis was on utilizing the existing research teams and facilities lo-

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[22] Basic Research in the Mission Agencies, op. cit., p. 323, citing Steward, Irvin. OrganizingScientific Research for War. Boston, Little Brown, 1948, p. 4.

[23] A History of Science Policy in the United States, 1940–1985, op. cit., p. 18.

[24] Brooks, op. cit., p. 937.

[25] Ibid.

> cated in the nation's universities and business laboratories, largely through the use of contracts.
>
> The OSRD was tremendously successful in applying science, engineering, and medicine to the conduct of the war. . . . The OSRD did provide profound and far-reaching precedents for the future organization of science in the United States. The contract system was so successful during the war that it set a pattern for postwar American science policy which remains to this day.[26]

For additional information about the origin and functions of DOD laboratories, see in this report, Chapter VI, "The Role Played by the DOD Laboratory Structure in the Conduct and Support of Research."

Many of the research management procedures and funding relationships (grants and contractual instruments) with universities and industry that were established by OSRD and its successors are reflected in the research support policies and mechanisms used today. Especially crucial was the OSRD policy of providing project grants to individual investigators to pursue a particular line of research.[27] (Most extramural peer review procedures and competitive research proposal mechanisms were not established until after World War II.) The Government/science relationship established during World War II generated a precedent for scientific centrally administered research. It ". . . made research and development big business. It also bound this R&D—done at both industrial labs and universities—to the Federal Government." [28]

### 2. THE DEVELOPMENT OF GOVERNMENTAL CONFIDENCE IN USING SCIENCE AND TECHNOLOGY FOR NATIONAL PURPOSES

With the war winding down, the enactment of the G.I. bill in 1944, which enabled returning soldiers to use Federal funds for educational purposes, generated a large flow of students into U.S. colleges and universities. This subsequently helped expand the pool of trained manpower needed for successful demobilization back to a civilian economy. And, according to Dr. Stine, the wartime successes inspired the view that science and technology could be harnessed by the Federal Government to achieve national goals:

> The research and development during World War II led to many new technologies that played a fundamental role in the outcome of the war. The most significant contributions included the atomic bomb, proximity fuse, computer, jet plane, penicillin, and DDT. The success and importance of these developments convinced political, military, and scientific leaders of the value of a continuing military research program. Indeed, the link between new technologies and military strength become so strong that the Federal

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[26] A History of Science Policy in the United States, 1940–1985, op. cit., pp. 18–19.

[27] The Impact of Increases in Defense R and D Expenditures on the U.S. Research System. In U.S. National Science Foundation. Emerging Issues in Science and Technology, Washington, U.S. Govt. Print. Off., 1982, p. 32-33.

[28] A History of Science Policy in the United States, 1940–1985, op. cit., p. 20.

Government could no longer leave science to its own devices.[29]

### 3. CREATION OF THE NATIONAL SCIENCE FOUNDATION

Senator Harley M. Kilgore, pleased with the success of the wartime OSRD policy and structure, but concerned that the OSRD would be disbanded after the war, held hearings during 1942–1945 on the general issue of Government support for scientific research and development. He introduced legislation to create a National Science Foundation in 1945. The success of OSRD also prompted President Roosevelt to encourage its director Vannevar Bush, to examine whether the wartime OSRD experiences could be used to maintain and enlarge the science/Government relationship after the war ended.[30] This resulted in preparation of the "Bush Report," *Science, The Endless Frontier,* which recommended ". . . enlightened Government support for scientific research and education . . . under a civilian-controlled organization, and the creation of a national research foundation," [31] action to support more graduate education, and programs to ". . . support medical research in the same way as weapons research. . . ." [32] This was followed by publication of the "Steelman Report", by the President's Scientific Research Board, in 1947, which contained recommendations to create national and Federal support programs for science, scientific manpower, and medical research.[33] Legislation to create the National Science Foundation (NSF) and the expansion of Federal programs to support students in the sciences and to assist universities in funding laboratories and other research infrastructure flowed directly from these reports. Allan Waterman, the chief scientist of the Office of Naval Research, which was created in 1946, became the first director of NSF in 1950.[34]

### 4. CREATION OF OTHER AGENCIES

Additional actions taken at the end of the war—in essence, to enable scientists to continue to conduct federally supported basic research—established the pluralistic basis of Federal science and research support policy that continues today. Emmanuel R. Piore explained as follows: ". . . each executive department and agency whose mission depended on "technology" and analysis had the "right" or responsibility to do or support research which was basic in character." [35] According to Harvey Brooks, "Much of the postwar era may be characterized as a struggle to 'civilianize' military science." [36] For instance, the Manhattan project which developed fission weapons, and the work of the Military Policy Committee, which acted as a board of directors for the Manhattan Project, were taken over by the agencies created by the Atomic Energy Act of 1946.[37] The Atomic Energy Commission's (AEC) received a large budget increase and efforts to develop a hydrogen bomb were given high priority following the Soviet nuclear test in 1949.[38] Much of the military medical research that OSRD had supported was shifted to the National Institutes of Health in the Public Health Service. The NACA was converted in 1958 to the National Aeronautics and Space Administration. Subsequently other kinds of research were located in separate agencies, such as the National Science Foundation, and the Department of Commerce.

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[29] A History of Science Policy in the United States, 1940-1985, op. cit., p. 20.

[30] For more details see: Dupree, A. Hunter. National Security and the Post-war Science Establishment in the United States. Nature, v. 323, Sept. 1986, p. 213.

[31] Basic Research in the Mission Agencies, op. cit., p. 324, citing Bush, Vannevar. Science the Endless Frontier: A Report to the President on a Program for Postwar Scientific Research, Washington, U.S. Govt. Print. Off., 1945, p. 1-4.

[32] Dupree, op. cit., p. 213.

[33] Basic Research in Mission Agencies, op. cit., p. 324, citing Steelman, John R. Science and Public Policy: A Program for the Nation. Washington, U.S. Govt. Print. Off., 1947.

[34] Brooks, op. cit., p. 938.

[35] Piore, Emmanuel R. Science, Government, and Policy. In Logsdon, John M. ed. The Research System in the 1980s. Public Policy Issues. Philadelphia, Pennsylvania, The Franklin Institute Press, 1982, p. 33.

[36] Brooks, op. cit., p. 937.

## D. CREATION OF THE DOD RESEARCH STRUCTURE

The Department of Defense was created with the enactment of the National Security Act of 1947. This established a Secretary of Defense, "who was to be primarily a coordinator, developing general policies for the three Executive Departments—the Army, the Navy, and the Air Force." [39] President Harry Truman disbanded the OSRD in 1947; its functions had been assumed in June 1946 by a Joint R and D Board, which was composed of two representatives from each branch of the Armed Forces and a civilian chairman, the first of whom was Vannevar Bush. As the Board established a coordinated military R and D program, "it sought to continue the military's close relationship with civilian scientists and universities." [40]

The passage of the National Security Act of 1947, which established the Department of Defense, also established a separate Department of the Air Force, the National Security Council, the Central Intelligence Agency, and the Research and Development Board, the successor to the OSRD and the Joint R&D Board, which coordinated military research during much of the Korean War period.[41]

The pressures of the Korean War led to a remobilization of military-related R&D which had been curtailed after World War II ended. In a 1953 reorganization of the Defense Department, the Board was terminated and its functions were expanded and transferred to two assistant secretaries (for engineering and for research and development). These were combined in 1957.[42] Following the competitive threat posed by the first national launch of an artificial satellite—the Soviet launch of Sputnik—civlian research support by the National Science Foundation was expanded and the White House President's Science Advisory Committee (PSAC) was created. (See Section J for details regarding DOD organization for R&D after 1957.)

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[37] York, Herbert F. and G. Allen Greb. Military Research and Development: A Postwar History. Bulletin of the Atomic Scientists, Jan. 1977: 14.

[38] York and Greb, op. cit., p. 17.

[39] U.S. Dept. of Defense. Facts 1982, p. 1. Stine in A History of Science Policy in the United States, 1940–1985, op. cit., cites the following as major sources of information about military support of research after World War II: Merritt Roe Smith, ed. Military Enterprise and Technological Change: Perspective on the American Experience (Cambridge, The MIT Press, 1985, p. 289–328; and Harvey M. Sapolsky, Academic Science and the Military: The Years Since the Second World War. In Nathan Reingold, ed., The Sciences in the American Context: New Perspectives, Washington, Smithsonian Institution Press, 1979, p. 379–399.

[40] A History of Science Policy in the United States, 1940–1985, op. cit., p. 32–33.

[41] York and Greb, op. cit., p. 15.

[42] Ibid., p. 18, 28–29.

## E. CREATION OF FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS

During World War II, several interdisciplinary, extramural research support projects had been initiated. They eventually evolved into several major think tanks and federally funded research and development centers (FFRDCs) which continue to operate today.[43] The FFRDCs are organizations created with Government funding primarily to do research and development for the Government that cannot be done effectively elsewhere. They are administered by an industrial firm, a university or college or other nonprofit institution.[44] They operate as private firms, although Congress or other sponsoring agencies can impose personnel and budgetary controls. The term FCRC, federal contract research center, as used by the DOD, is a subset of FFRDC.

The origin and rationale for DOD FFRDCs has been described as follows:

> Most DOD FFRDCs (a total of 39) were established between 1942 and 1963 when, for various reasons (e.g., lower pay than in the private sector and slow hiring procedures), the Pentagon was not able to attract the scientific and technological talent necessary to meet their broad research needs. Further, DOD realized that most of the technical talent was located in "hardware" companies that had a strong vested interest in the support of certain Pentagon research and development. Consequently, rather than contracting with these companies, DOD developed FFRDCs to provide it with objective science and technology advice on solutions to problems which had been experienced by the Federal Government during World War II.[45]

The Department of Defense has identified three basic types of FCRCs and described their origins. The first is the "true technology-oriented laboratory." The first of these was the Applied Physics Laboratory at the Johns Hopkins University, organized in 1942 at the request of the Office of Scientific Research and Development. It served as the precursor and model for many subsequent FCRCs. According to DOD:

> Its purpose was to give central direction and technological support to the association of contractors from universities and industry then being organized by OSRD to exploit, in the defense of U.S. naval forces, the ideas on radio proximity fuzes that had just been developed. By 1944, APL/

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[43] Ibid., p. 15.

[44] This definition is substantially in accord with the definition used by the National Science Foundation in the series Federal Funds for Research and Development. Fiscal Years 1980, 1981, and 1982. V. xxx. Detailed Statistical Tables. Washington, U.S. Govt. Print. Off., 1981, p. 3, NSF 81-325.

[45] U.S. Library of Congress. Congressional Research Service. DiMaggio, Cosmo and Michael E. Davey. The Strategic Defense Initiative Institute. An Assessment of DOD's Current Proposal. Prepared at the Request of the Hon. Paul Simon and Hon. William Proxmire. May 30, 1986, p. 5.

> JHU's contract had been taken over directly by the Navy Department, and its fleet air defense effort was directed to the development of the technology of shipborne surface-to-air guided missiles—a sponsorship and effort that have continued ever since. From this came the ideas of the private R&D organization tailored to serve as a continuous agent of the Defense Department in a broad mission area in which the DOD lacked sufficient internal technological and technical-management capabilities.[46]

Other FCRCs of this type were the Lincoln Laboratory at MIT, established in 1951 to do research to assess the contribution that large computers could make to air defense and the Ordnance Research Laboratory (ORL) established in 1945 at Pennsylvania State University.[47]

A second type of private support organization does studies and analyses. According to DOD, the general impetus for creation of groups of this class of institutions was:

> To create or retain a group of scientifically and technically oriented professionals capable of serving as independent, objective sources of analysis, evaluation and advice on general and specific problems of national security.[48]

This kind of institution originated with Project Rand, a think tank created as an autonomous division of the Douglas Aircraft Company. Rand had been started during the war to provide advice to the Army Air Forces on the application of technology to aerospace. In 1948, it became the Rand Corporation, an independent firm whose analyses and other services were broadened beyond technology and the interests of the Air Force.[49] In contrast to the Applied Physics Laboratory, which focused on technology development, "Rand devoted itself largely to the analytic study of national security, providing objective research, analysis and advice to the Air Force (and others) across a broad spectrum instead of doing laboratory-based technological work or hardware development." [50] Other bodies of this type have included the Research Analysis Corporation; the Center for Naval Analysis, which originally was operated by the University of Rochester and then the Hudson Institute; the Human Resources Research Organization (HumRRO); and the Institute for Defense Analyses (IDA).

The Institute for Defense Analyses and similar organizations had been created shortly after the war:

> In 1948, the Secretary of Defense and the Joint Chiefs concluded that they . . . needed an operation analysis group working closely with them. To that end, they set up the Weapons System Evaluation Group (WSEG). The

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[46] Office of the Director of Defense Research and Engineering. Report of the Special Study Group on Federal Contract Research Centers (FCRCs). Aug. 30, 1971. Washington, U.S. Govt. Print. Off., 1971, p. 5.

[47] For detailed information about the historical origins of the facilities, see: Report of the Special Study Group on Federal Contract Research Centers, op. cit., p. 5-7.

[48] Report of the Special Study Group on Federal Contract Research Centers, op. cit., p. 7.

[49] York and Greb, op. cit., p. 16.

[50] Report of the Special Study Group on Federal Contract Research Centers (FCRCs), op. cit., p. 5.

> group was commanded by a senior flag rank officer, it was physically located in the Pentagon, and it consisted of a mixed group of military and civilian experts of various kinds. Within just a few years, it was found that the kind of civilians needed could not be recruited in sufficient numbers under such an arrangement. So the Institute for Defense Analyses (IDA) was created in 1956 to provide a separate civilian-oriented administration for the group; initially it was a consortium of universities put together by James Killian, but now it is a free-standing not-for-profit corporation.
>
> In 1958, IDA's scope was expanded to include similar work for the top civilian officers in the Department of Defense. Like RAND, it continues today to do the same sort of work. The Navy and the Army have had similar institutions working for them, namely, the Center for Naval Analysis (CNA) and Research Analysis Corporation (RAC).[51]

The third type of FCRC does systems-engineering/technical direction types work and typically is an independent nonprofit corporation. Firms of this sort include Mitre,[52] and Aerospace.[53] Both of these firms were organized in 1960, under Air Force sponsorship, in part "as a result of much congressional criticism of the heavy dependency on profit-making, hardware-producing corporations for management and support in the ballistic missile field." In the case of Aerospace the objective was to create an organization that would not object to a ban on the production of hardware, which profit making firms would find difficult to accept.[54]

Recently, there has been discussion about making the Arroyo Center, operated by RAND, into a separate "think tank," for the Army. The Pentagon has also announced controversial plans to develop a "think tank," called the Strategic Defense Initiative Institute, to advise on technologies to meet the objectives of President Reagan's Strategic Defense Initiative program. Questions have been raised about the staffing, independence, and funding of the institute.[55]

(The armed services also utilize the facilities of government-owned, company-operated firms, such as the Ponoma Division of General Dynamics; Allegany Ballistics Laboratory (Hercules); and Oak Ridge National Laboratory (Union Carbide and Martin-Marietta); as well as the services of the defense industry firms, such as TRW, Lockheed Missiles and Space, and Texas Instruments.)[56]

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[51] York and Greb, op. cit., p. 16.

[52] See: Mitre: The First Twenty Years. A History of the Mitre Corporation (1958–1978). Bedford Massachusetts, The Mitre Corporation, 1979, 288 p.

[53] Report of the Special Study Group on Federal Contract Research Centers, op. cit., p. 5.

[54] Report of the Special Study Group on Federal Contract Research Centers, op. cit., p. 7.

[55] See for example: Strategic Defense Initiative Institute. Remarks of Senator Levin. Congressional Record, May 12, 1986: S5 781–S5784 and The Strategic Defense Initiative Institute: An Assessment of DOD's Current Proposal. Prepared at the request of the Honorable Paul Simon and Honorable William Proxmire. By Cosmo DiMaggio and Michael E. Davey. Congressional Research Service. Library of Congress, May 30, 1986, 23 p.

[56] Long, Franklin A. and Judith Reppy, eds. The Genesis of New Weapons: Decision Making for Military R&D. New York, Pergamon Press, 1980, p. 63–65.

Problems with the FCRCs have been raised since their inception. The comments of a report prepared by DOD in 1971 bear repeating today:

> The tone and themes of congressional comments 10 years ago—too much growth, too great a cost to the government, too little control, and poor-quality products—have been repeated in almost every succeeding year.
>
> Clearly, as viewed by the Congress, attempts by the DOD and the FCRCs to respond to congressional concern have not been completely successful.
>
> There has also been criticism to the Congress from industry, both profit and nonprofit, that the FCRDs which make studies and analyses and systems engineering/technical direction * * * are, in practice, doing work that industry should do.[57]

The FCRCs however, complained that ceilings imposed on funding shrink their capabilities and that their efforts at client diversification have not been successful.[58] The Defense Science Board also studies the issue of use of the FCRCs in 1976 and made recommendations to the Director of Defense Research and Engineering to improve their functioning.[59]

The number of FFRDCs was decreased over time as follows:

> Between 1942 and 1963, DOD had established 39 FFRDCs. This rapid growth of independent research organizations began to raise serious concerns in Congress. Critics in Congress and elsewhere felt that the Pentagon was placing too much of its sensitive research and policy-related work with these independent external groups. Further, most of the FFRDCs were originally established to conduct R&D in areas in which the Government did not yet have expertise. As DOD in-house capabilities expanded, Congress expected the number of FFRDCs to decrease, something that was not happening. However, as a result of continuing congressional pressure, DOD announced in 1964 that it would reduce the number of FFRDCs from 39 to 21. The Pentagon contended that many of the centers had completed their original mission and were no longer capable of responding to DOD's changing needs. Reductions continued in the following years and by 1976, the Pentagon had reduced the number of FFRDCs it supported to six.[60]

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[57] Report of the Special Study Group on Federal Contract Research Centers (FCRCs), op. cit., p. 9.

[58] Ibid., p. 8.

[59] Report of the Defense Science Board Task Force on Federal Contract Research Center Utilization. Washington, D.C., Feb. 1976, 40 p.

[60] DiMaggio and Davey, op. cit., p. 5-6. For additional information regarding university-affiliated military FFRDCs--see chapter IV, An Overview of DOD Support for Research at Colleges and Universities.

## F. THE SERVICES' RESEARCH STRUCTURES

The Office of Naval Research (ONR) was established by statutory authority on August 1, 1946 (Title 10 U.S.C. 5150–5153)[61] at the prompting of naval officers and scientists who wanted to avoid a dismantling of the scientific research support structure and research infrastructure which had been created in World War II.[62] ONR was the first Government agency to "sponsor contract research systematically"[63] and it was the first "government organization to formally support basic research" in a variety of fields (the National Science Foundation was not created until 1950).[64] From the outset it established procedures and policies that were to become standard for civilian and military support of research. Dr. Stine explained as follows:

> A regular Navy officer was made director of ONR, while a civilian chief scientist served as deputy director and administered the various programs. A Naval Research Advisory Committee was also established in 1946 and, along with numerous other special committees and panels, it brought eminent civilian scientists to the service of the Navy as advisors on projects and screeners of research proposals—thus providing an early and successful peer review system.
>
> Although ONR's main purpose was to support scientific research related to Navy's defense mission, it was also charged with sponsoring and promoting a broad array of basic research. Indeed many of its early research projects had little apparent bearing on defense issues. The ONR was quick to establish good relations with the nation's universities, and the scientific community came to view its program as a great success. Its research support was carried out largely through contracts with universities—a continuation of the principal method used by the OSRD—and its contracts were awarded on the basis of scientific merit. Its support of research was both generous and relatively free of administrative or programmatic restrictions, thus helping to ensure academic freedom.[65]

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[61] For additional details see: Old, Bruce S. The Evolution of the Office of Naval Research, Physics Today, v. 14, Aug. 1961, Men and Decisions, by Lewis L. Strauss, Doubleday and Company, Inc.; 1962, and Ships, Machinery and Mossbacks, Vice Ad. Harold G. Bowen, Princeton University Press; as cited by: Return on Investment in Basic Research—Exploring a Methodology. Report of Office of Naval Research, Department of the Navy by Bruce S. Old Associates, Inc., Concord, Mass., Nov. 1981, p. 8.

[62] Roger L. Geiger of Yale University offers an entirely different perception of the origin of ONR. He weaves an argument to show that it was part of a bargain that allowed the Navy to hold nuclear power research. (Geiger, Roger L. Milking the Sacred Cow: Research and the Quest for Useful Knowledge in the American University, 1920–1986. Prepared for the Engineering Foundation Conference. University-Industry-Government Cooperation in Research and Technology Transfer. Heniker, N. H., July 20–25, 1986, p. 16–17.

[63] Young, Leo. The University Link. Defense 83. Feb. 1983: 5.

[64] Suttle, op. cit., 50. See also: Office of Naval Research. Windows to the Origins. By R. D. Hagen. 1986, 46 p.

[65] A History of Science Policy in the United States, 1940–1985, op. cit., p. 33 Stine cites the following as other sources of information about ONR: David K. Allison, U.S. Navy Research and Development Since World War II, in Military Enterprise and Techological Change; Perspective on the American Experience, op. cit.; Arthur D. Little, Inc. Basic Research in the Navy: A Report to the Naval Research Advisory Committee, 2 vols. Cambridge, n.p. 1959; F. Joachim Weyl, ed. Research in the Service of National Purpose: Proceedings of the Office of Naval Research Vicennial Convocation. Washington, U.S. Govt. Print. Off., 1966.

David Dickson wrote that the office's importance to civilian science is evidenced by the fact that:

> By 1950 the ONR had already provided research contracts to 200 universities for 1,200 separate research contracts. In the first postwar decades it financed about half the students taking doctorates in the physical sciences and sponsored much subsequent basic research in areas ranging from high energy physics to x-ray astronomy.[66]

The enduring legacy of the ONR in shaping the American science/government relationship was described in a National Science Foundation document:

> The Office of Naval Research (ONR), established in 1946, was by 1950 supporting over 40 percent of U.S. basic science and had developed a variety of means of providing this support. Most of those means are still in use today. They include:
>
> —Funds for construction of large facilities operated by a consortium of universities;
>
> —Funds for large single-university laboratories, with the research agenda set by a single laboratory director;
>
> —Acquisition of expensive, specialized equipment;
>
> —Funding for unique institutions such as Woods Hole Oceanographic Institute; and
>
> —Project grants to individual investigators to pursue a particular line of research.[67]

The Army Research Office was established in 1951 and, despite considerable resistance to basic research in the Air Force,[68] the Air Force Office of Scientific Research was established in 1952.[69]

Laboratories which had been under military control of the U.S. Army's Manhattan Engineering District during World War II, for instance, Los Alamos, Oak Ridge, and Argonne were transferred to civilian control although they continued to do weapons and related military research.[70]

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[66] Dickson, David. The New Politics of Science, New York, Pantheon Books, 1984, pp. 118–119.

[67] The Impact of Increases in Defense R&D Expenditures on the U.S. Research System. In U.S. National Science Foundation. Emerging Issues in Science and Technology, 1982. A Compendium of Working Papers for the National Science Foundation. Washington, U.S. Govt. Print. Off., 1982. p. 32–33, citing Piore Emmanuel. Science, Government and Policy, A Four-Decade Perspective. In Logsdon, John M. ed. The Research System in the 1980s: Public Policy Issues. Philadelphia, Franklin Institute Press, 1985, p. 2.

[68] See: Komons, Nick A. Science and the Air Force. A History of the Air Force Office of Scientific Research. Arlington, Va., Office of Aerospace Research. Washington, U.S. Govt. Print. Off., 1966; Greenberg, D.S. The Air Force: Study Relates Troubled Relationship with Research. Science, June 16, 1967: 1463–1466.

[69] Stine in History of Science Policy in the United States, 1940–1985, cites the following as additional sources of information about the AFOSR: Thomas A. Sturm, The USAF Scientific Advisory Board: Its First Twenty Years, 1944–1964, Washington, U.S. Govt. Print. Off., 1967, and William J. Price, et al, Science-Technology Coupling: The Experience of the Air Force Office of Scientific Research in William H. Bruber and Donald G. Marquis, eds. Factors in the Transfer of Technology, Cambridge, The MIT Press, 1969, p. 117–136. See also York and Greb, op. cit., p. 16–17.

[70] See for example, Piore, op. cit., p. 34. 6

## G. The Curtailment of the National Science Foundation's Military Research Functions

The report by Vannevar Bush, *Science, the Endless Frontier,* which developed the rationale for creation of a Government agency to support civilian scientific research, had envisioned creation of a National Research Foundation as the "central agency of U.S. science policy," It would have had divisions for different kinds of research, including medical, and would have centralized support for "long-range oriented military research." [71] In actual fact, the offices of scientifc research in each of the services as well as the Advanced Research Projects Agency (ARPA) and its successor, the Defense Advanced Research Projects Agency (DARPA) were created to oversee military research.[72] The military's control over its own research policies was reinforced with several actions in the early 1950s. The agency finally created to centralize Government research support, the National Science Foundation (NSF) had been given wide authority to support defense research by its enabling legislation in 1950. Specifically it has been authorized at the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters relating to the national defense by making contracts or other arrangements (including grants, loans, and other forms of assistance) for the conduct of such scientific research (P.L. 11-507, sec. 3(a)(3)).

However, this provision was modified with the passage of the NSF amending legislation in 1968 (P.L. 90-407) which limited the authority of NSF to support defense-related research unless it met the following provisions: it had to be nonclassified, it had to be financed by a transfer of funds from that agency to NSF if feasible, and sponsorship by DOD was to be identified. (National Science Foundation. Statutory Authority, Feb. 1986, Sec. 3(b)). In addition, early in the NSF history the director made the decision "to limit NSF's science policy authority", a coordination function over other Federal agencies that it had been given by the Bureau of the Budget and formally via Executive Order 10521, issued by President Eisenhower on March 17, 1954. The first NSF Director Alan Waterman believed that the agency could not fully implement these responsibilites "partly because its position within the Government hierarchy did not grant it authority over other agencies and departments." [73]

## H. Activities Related to the Korean War

Another event which affected military research and which would later have civilian implications, was the creation of the Science Advisory Committee (SAC) in the Office of Defense Mobilization in 1951—to provide the White House with overall scientific advice on mobilization planning for the Korean conflict.[74] This office was a predecessor of the President's Science Advisory Committee.[75]

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[71] Bush, op. cit., p. 939.

[72] A History of Science Policy in the United States, 1940-1985, op. cit., p. 34.

[73] A History of Science Policy in the United States, 1940-1985, op. cit., p. 37.

[74] See also: York and Greb, op. cit.

[75] A History of Science Policy in the United States, 1940-1985, op. cit.

U.S. defense policy and strategy, including the management of R&D, were thoroughly revised in late 1952 and 1953 following the inauguration of President Eisenhower, the cessation of Korean hostilities and the first successful hydrogen bomb explosion by the United States.[76] A new focus came to be placed on reducing troop levels, and on emphasizing military technology. To implement the new doctrine of "massive retaliation," three major changes were made in the management of R&D in the military:

> First, the Research Development Board and its system of part-time committees was abolished and replaced by two separate full-time staffs, each headed by an Assistant Secretary of Defense [for Research and Development, and for Applications Engineering]. Second, the practice of handling the increasingly large and important missile program separately from the rest of military R and D was continued but greatly strengthened and expanded. And third, the human resources available to SAC/ODM [the Scientific Advisory Committee in the Office of Defense Mobilization] were effectively mobilized in the form of two special study panels: the Technological Capabilities Panel (Killian, 1954) and the Security Resources Panel (Gaither, 1957).[77]

Basically this change ". . . had the broader objective of confirming for the first time the absolute authority of the Secretary of Defense over the operations of the individual military departments." [78] Several congressional hearings were held and reports were issued about these topics.[79] The Killian panel apparently ". . . exercise[d] an unusal degree of influence over the technological future" since it recommended emphasis on specific kinds of technological development and weapons systems that were, in fact, pursued.[80] The Gaither committee recommendations, dealing with national security and intelligence issues, "became a political football is the national debate over the missile gap that followed in the wake of Sputnik." [81]

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[76] York and Greb, op. cit., p. 20.

[77] Ibid.

[78] Ibid.

[79] See for instance: U.S. Congress. House. Committee on Government Operations. Organization and Administration of The Military Research and Development Programs. Hearings before a Subcommittee. 83rd Cong., 2nd Sess. June 1954, 710 p.; U.S. Congress. House. Committee on Government Operations. Research and Development (Office of the Secretary of Defense). Thirty-second report. 85th Cong., 2nd session. House. Rept. No. 2552. Washington, U.S. Govt. Print. Off., 1958, 218 p.; U.S. Congress. House. Committee on Science and Astronautics. Basic Scientific and Astronautic Research in the Department of Defense. Hearings before Subcommittees Nos. 1, 2, 3, and 4. 86th Cong., 1st Sess., June 1959, Washington, U.S. Govt. Print. Off., 1959, 536 p. U.S. Congress. House. Committee on Science and Astronautics. Basic Scientific and Astronautic Research in the Department of Defense. 86th Cong., 1st Sess. House. Report. 1182, no. 31. Sept. 11, 1959, 33 p.

[80] According to York and Greb: "The panel's support of the ICBM programs, by then already underway, aided in securing the 'highest national priority' for them. Its recommendation that both land-based and sea-based intermediate-range missiles be developed led directly to the initiation of the Thor, Jupiter and Polaris programs. The panel's conclusions and recommendations concerning technological intelligence, both the need for it and the means to get it, led directly to the development and use of the U-2 spy-plane, and served to give essential support to the Air Force's plans for building reconnaissance satellites." (York and Greb, op. cit., p. 22.)

[81] York and Greb, op. cit., p. 22.

## I. Activities Following the Launch of Sputnik in 1957

Military enthusiasm for funding basic research "began to wane in the mid-1950's, just as it had done twenty years earlier. DOD funding for basic science remained almost constant between 1952 and 1957, leading to a drop of about 25 percent in real terms because of the impact of inflation."[82] In 1957, the Pentagon announced that it would cut its research budget by 10 percent.[83] Shortly thereafter, however, Federal policies for civilian and military R&D were redirected following both the orbiting by the Soviet Union in October 1957 of a satellite called Sputnik and by the Soviet orbiting and recovery of an astronaut before the United States. These events "shattered American complacency" about the purpose and size of national, especially Federal, support policies for research and development and for science education, and led to a surge of public support for science.[84] As a result of the reaction to Sputnik, according to the National Science Board, "All federally funded basic research obligations quadrupled between 1958 and 1966." Specifically:

> That this movement was broadly based is illustrated by the fact that it took only 2 years for the basic research obligations of the Department of Health, Education, and Welfare (HEW) and of the NSF to double, with the Atomic Energy Commission (AEC) achieving this the following year and the Department of Agriculture a year later. Total Federal outlays related to research and development rose from 6 percent of all Federal outlays in FY 1958 to 12.6 percent in FY 1965 (and back down to 6 percent in FY 1975).[85]

### 1. CREATION OF NASA

In addition to raising Federal R&D budgets throughout the Government, during the ten years after the launch of Sputnik, Congress enacted legislation aimed at strengthening the base of U.S. space science and technology. The National Aeronautics and Space Act, signed into law on July 29, 1958, created "the National Aeronautics and Space Administration (NASA) and ensured that the U.S. space progam would be a civilian, rather than a military effort." The creation of NASA enlarged the pool of federally supported extramural research and development, especially that performed by universities, both on hehalf of the space effort and in support of general science functions.[86]

### 2. NATIONAL DEFENSE EDUCATION ACT

In addition the Congress formally recognized the importance and relevance of education to national security with the passage of P.L. 85-864, the National Defense Education Act of 1958, (NDEA). This law was intended to provide funding to allow all qualified students access to higher education (in contrast to the NSF act which directed funds primarily toward training scientists and technologists, mostly at the graduate level, and on a highly competitive, "elitist" [87] basis). The Act also was designed to help improve precollege and college level science education in order to counter Soviet achievements in scientific manpower training and research. It also served other defense-related purposes, by providing loans to college students, supporting modern foreign language training, and widening the distribution of fellowship awards to a broader pool of schools, beyond the typical prestigious reseach producing institutions funded typically by the National Science Foundation.[88]

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[82] Dickson, op. cit., p. 119.
[83] Ibid., p. 119.
[84] Basic Research in the Mission Agencies, op. cit., p. 324.
[85] Ibid.
[86] A History of Science Policy in the United States, 1940-1985, op. cit., p. 42.

### 3. WHITE HOUSE SCIENCE OFFICE

Another reaction to Sputnik consisted of reconstituting and elevating the science advisory apparatus in the White House. On November 7, 1957 President Eisenhower announced the creation of the Office of Special Assistant to the President for Science and Technology, and appointed a science advisor. On November 27, he transferred the Science Advisory Committee of the Office of Defense Mobilization to the Executive Office of the President, enlarged it, and renamed it "the President's Science Advisory Committee," PSAC.

### 4. CREATION OF ADVANCED RESEARCH PROJECTS AGENCY

Another reaction to Sputnik was the establishment by statute, P.L. 85-325, of 1958, of the Advanced Research Projects Agency (ARPA), now called the Defense Advanced Research Projects Agency (DARPA). ARPA was created "partly from the pressures caused by the launching in Sputnik and partly in response to the urgent need for high-level attention to selected research projects stemming from promising advanced concepts and requiring long-range developments and tests." [89]

The idea of creating ARPA has been attributed to James Killian, who was the Presidential Science Advisor, and Neil McElroy, who was then the Secretary of Defense, as a way to end the ". . . rivalries between the military services [which] had by this time nearly paralyzed the U.S. space effort: [90]

> Dismayed at being caught flat-footed by the Russians, President Eisenhower asked how such a strategically important advance could fall through the cracks. The answer was partly organizational. No agency or service was accountable . . . for . . . such revolutionary long-term research projects. Thus DARPA was established to cut across the traditional jurisdictions of the armed services and to maintain a technological vigil to assure that the technology available for national security was second to none.

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[87] Wilson, John T. Academic Science, Higher Education, and the Federal Government, 1950-1983. Chicago, the University of Chicago Press, 1983, p. 46.

[88] Ibid., p. 76.

[89] U.S. Dept. of Defense. Basic Research Program, 1980, p. 45.

[90] Lerner, Eric J. Technology and the Military: DOD's DARPA at 25. IEEE Spectrum, v. 20, Aug. 1983, p. 72.

> Initially DARPA spearheaded the space race. Shortly thereafter the National Aeronautics and Space Administration was established, and selected DARPA personnel were transferred to the new agency, including the Saturn-booster program.[91]

During the Kennedy administration, DARPA branched out into other research areas, including information-processing, computer graphics, interactive computing and natural language communication.[92] During this period, it also "* * * frequently ended up funding projects of greater scientific value that, in some cases, had only peripheral relevance to defense. The huge 500-meter radio telescope at Arecibo, Puerto Rico, was originally started as part of the antiballistic missile program." [93] Eventually support was shifted to the NSF and the telescope became part of the atmospheric and astronomical research support program. Sociological research geared to understanding cultural factors and nonmilitary solutions to conflicts were funded under Project Agile. Recently, spaced-based laser and particle-beam systems [94] and testing work have been important to DARPA.

For additional information about DARPA see chapter IV in this report.

### J. ORGANIZATION OF THE DOD FOLLOWING THE LAUNCH OF SPUTNIK

The Secretary of Defense's authority for centralizing R&D increased gradually over time in response to the launching of Sputnik.

Before the passage of the Defense Department Reorganization Act of 1958 (P.L. 85-599) three parts of the Office of the Secretary of Defense had responsibilities related to military R&D: the Director of Guided Missiles, the Advanced Research Projects Agency, and the Assistant Secretary of Defense for Research and Engineering. There was some confusion about lines of authority because each office had parallel and somewhat conflicting jurisdiction, especially for the fields of missile and space technology. The Reorganization act abolished the post of Assistant Secretary for Defense Research and Development, and established an Office of Director of Research and Engineering with responsibility for all research and engineering in the Pentagon. The director was also named the principal adviser to the Secretary of Defense on matters of science and technology. DOD reports that:

> The new Director was charged not only with being the principal adviser to the Secretary of Defense in all scientific and technological matters, but also with supervising all research and engineering activities in the Department of Defense and directing and controlling those activities. . . .[95]

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[91] Botkin, James and Dan Diamancescu. The DARPA Exception. In Conclusions and Countercurrents. Chap. 10, in Tirman, John, ed., The Militarization of High Technology. Ballinger Publishing Company, Cambridge, 1984, p. 222.

[92] Lerner, op. cit., p. 73.

[93] Ibid.

[94] Ibid.

[95] U.S. Dept. of Defense. Facts, 1982, op. cit.

One view is that the Act gave the Director of Defense Research and Engineering (DDR&E) more authority and greater scope than the Assistant Secretary had. Specifically:

> . . . the Assistant Secretary had been largely limited to advisory and coordinating program actions whereas the DDR&E had direct authority to approve, disapprove or modify all R&D programs of the Defense Department. This last meant that such key programs as ballistic missiles and satellites ceased to be separately managed, and were combined with all other research and development programs. The formal status of the DDR&E in the Defense Department was also legally modified so as to give him precedence equal to that of the service secretaries and ahead of all the other assistant secretaries.[96]

The first director of Defense Research and Engineering was Herbert York, who had been a director of the AEC's Lawrence Livermore Laboratory and chief scientist of ARPA, and was also a member of the President's Science Advisory Committee. A subsequent Director of Defense Research and Engineering was Harold Brown, also a member of PSAC. Several of the early directors were former directors of Lawrence Livermore Laboratory.[97] Other directors were: John S. Foster, Jr., former director of Lawrence Livermore Laboratory; Malcolm Currie, formerly with Hughes Aircraft and vice-president for research and development at the Beckman Corporation; William Perry; and Richard DeLauer, formerly executive vice president of TRW.

Shortly, after the creation of ARPA, a conflict arose because the Office of the Director of Defense Research and Engineering had been given broad responsibilities for the direction of military basic research. In an attempt to eliminate duplication of effort with ARPA, the Department issued a directive, 5105.15, March 17, 1959, which assigned the Director of Defense Research and Engineering responsibility for the supervision and coordination of ARPA activities with those of the Army, Navy, and Air Force.

Each service has an R&D coordination structured similar to DDREE:

> At about the same time the current system of R&D management was being established in the Department of Defense, similar structures were created in each of the three military departments. In each case, the highest civilian R&D official is called the Assistant Secretary (of the Army, Air Force, or Navy) for R&D, and the highest uniformed official usually has the title Deputy Chief for R&D. Since the 1950s, the top-level civilians have all been professional scientists or engineers with substanital management experiences, and the officers usually have had both advanced academic training in technology as well as considerable R&D management experience. Generally, the authority of these officials is not great; their main function is

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[96] York and Greb, op. cit., p. 24.
[97] Ibid., p. 25.

> to serve as staff assistants to the service secretary and chief of staff, respectively, and in effect to the DDR&E as well.[98]

According to Dr. Harvey Brooks, the Department of Defense became the preeminent Federal agency to support certain kinds of research, because the defense agencies had the ability "to act quickly [which] tended to result in their being able to establish a position in many of the most exciting frontier fields of research. . . .[99] These fields include:

> Elementary particle physics, computer science, modern theory, quantitative behavioral science, molecular biology, sensory psychology, satellite technology, radio-astronomy, x-ray and gamma-ray astronomy, cryogenics, and high pressure physics.[100]

However, as new Federal research support agencies were subsequently established, funding responsibilities for some fields of science was transferred,

> For example, by agreement the National Science Foundation assumed increasing responsibility for low temperature physics after 1954. In the late 1960's (sic) an agreement was reached by which ONR's remaining nuclear physics projects in universities were to be largely transferred to NSF. In 1965, NSF was assigned responsibility as "principal agency" for the support of ground based astronomy, and partly as a consequence, the military services began phasing out of radio astronomy.[101]

Some observers point out that military problems have often stimulated the development of important new areas of basic research such as mathematical linguistics and non-linear optics and have provided new experimental techniques and tools, such as computers and microwave components, that have accelerated fundamental scientific advance.[102]

### K. CRITICISMS OF MILITARY-INDUSTRIAL COMPLEX

In 1961, in his farewell address as president, Dwight D. Eisenhower warned of the threats posed by a growing "military-industrial complex". He conceptualized this as a close relationship between the Department of Defense, military contractors, and scientists and technologists working in weapons research, which could lead to political domination by a singular elite and declines in productivity and civilian output if such a decisionmaking "complex" used excessive amount of U.S. resources. Shortly thereafter, due perhaps to this warning as well as to the creation and expansion of Federal agencies which supported research (especially the National Science Foundation and the National Aeronautics and Space Administration) and the Vietnam War buildup which utilized defense resources, the proportion (but not the amount) of Federal R&D funding that went to defense work declined. In 1961, 79 percent of Federal R&D outlays went to defense; the percentage decreased to 63 percent in 1963 and 49 percent in 1966. During the period of the late 1960s and early 1970s about 50 to 55 percent of Federal R&D funds went to support defense work. This percentage declined to about 49–50 percent in the late 1970s. The percentage of Federal funding that went to military work continued to decrease and averaged about 50 pecent until large increases in military R&D of the early 1980s. The percentage of Federal R&D funding for defense purposes during the 1980s is approaching the high levels that were attained during the period that immediately preceding President Eisenhower's warnings, reaching over 70 percent in 1986.[103]

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[98] Ibid.
[99] Brooks, op. cit., p. 944.
[100] Ibid.
[101] Ibid.
[102] Ibid., p. 945.

## L. Criticisms of Military Research Funding

NSF data show that the Defense Department funded close to 60 percent of Federal research (as opposed to R&D) in the late 1950s. This started decreasing after the creation of large research programs in other agencies, to about 37 percent in 1964, 30 percent in 1975 and about 21 percent in 1985.

Federal funding for defense research began to fall in the late 1960s as a percentage of DOD R&D funding. Several factors contributed to this trend. One is the exigencies of the Vietnam war—"an unpopular war"[104]—and accompanying it, as is typical of wartime situations, a shift from funding research, which may have long-term payoffs, to short-term funding which promotes the development of weapons and devices which are sought to win battles and save the lives of soldiers in the field. During the late 1960s and early 1970s, students and some faculty on many campuses criticized researchers who did work, especially classified research for the Department of Defense. Some also objected to military applications of their research in the Vietnam war, which many opposed.

Accompanying this was the criticism of DOD funded social science research in other countries, some of which, it was charged, subverted revolutionary movements and was conducted by university researchers; criticism of DOD funded classified research on campuses; and student agitation to reduce or eliminate ROTC military training programs on campuses and to eliminate DOD funded R&D on campuses. There were also acts of physical violence and bombings and harassments of students and professors associated with DOD sponsored work. Military research funding to universities subsequently declined. (See Chapter V, Overview of DOD Support for Research at Colleges and Universities.)

### 1. CUTBACK IN UNIVERSITY RESEARCH

This opposition to military research funding on campus also had the tangible effect of causing major universities to cut their ties with military supported classified research centers and to prohibit the conduct of classified military research on campuses. Universities had established separate facilities or centers to do military research to conform to the requirements for classification. For details about the establishment and subsequent divestment by universities of some of these research centers, see chapter V in this report.

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[103] Table 10. 1F. Summary of Outlays for the Conduct of Research and Development: 1949–1987. In: U.S. Office of Management and Budget. Historical Tables, Budget of the United States Government. Fiscal Year 1987. Washington, U.S. Govt. Print. Off., 1986.

[104] U.S. Dept. of Defense. Basic Research Program, 1984, p. 4.

By 1975, most of the university-managed, defense cosponsored FFRDCs that had existed in 1966 had been phased out. As a summary:

TABLE III.B.—CHANGE IN STATUS OF UNIVERSITY-AFFILIATED FFRDCs and LABS 1966 TO 1975 [105, 106]

| FFRDC | University administrator | Change in status |
|---|---|---|
| Applied Physics Lab | Johns Hopkins University | |
| Applied Physics Lab | University of Washington | Phased out 1974 |
| Applied Research Lab | Pennsylvania State University | |
| Army Mathematics Research Center | University of Wisconsin | Phased out 1970 |
| Center for Naval Analyses | University of Rochester | Became university administered 1968 |
| Center for Research in Social Systems | American University | Phased out 1970 |
| Cornell Aeronautical Laboratory | Cornell University | Divested 1969 |
| Draper Instrumentation Laboratory | Massachusetts Institute of Technology | Divested 1970 |
| Electronics Research Lavoratory | Columbia University | Divested 1967 |
| Human Resources Research Organization | George Washingion University | Changed to nonprofit administered 1969 |
| Hudson Laboratory | Columbia University | Phased out 1969 |
| Lincoln Laboratory | Massachusetts Institute of Technology | |
| Stanford Research Institute | Standford University | Divested 1970 |
| Willow Run Laboratories | University of Michigan | Divested 1972 |

[105] The National Science Foundation also listed the following as Federal Contract Research Centers funded by military departments and administered by educational institutions in 1966: Department of the Army: Special Operations Research Office (American University), Research Analysis Corporation; Department of the Navy: Arctic Research Laboratory (University of Alaska), Navy Biological Laboratory (University of California), and Ordnance Research Laboratory (Pennsylvania State University). (Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1965, 1966, and 1967, v. XV, NSF 66-25.

[106] A History of Science Policy in the United States, 1940-1985, op. cit., p. 61-62, citing Smith, Bruce L. R. and Joseph J. Karlesky. The State of Academic Science: The Universities in the Nation's Reserach Effort. New York, Change Magazine Press, 1977.

However, many of these centers still operate, and are often staffed by professors who have joint appointments at the university and the laboratory.[107]

It should be pointed out however, during this period the military services recognized the importance of scientists and engineers to the Nation's future because some scientists and engineers were exempted from the draft. Partially as a result, enrollments in science and technology programs shot up, only to decrease when the selective service was replaced by a lottery system.

### 2. PROJECT CAMELOT

Congressional attitudes towards military research on campus were shaped also by the congressional criticism of Project Camlot in the late 1960s. This project used military-funded, U.S. social science researchers to do socio-economic research relating to counterrevolutionary movements. Scientists at the American University and the University of Michigan were among the principal investigators. When Chilean governmental and scientific leaders protested the research, which, they said represented an attempt to thwart democratic revolutions and which, they charged they were not informed about, Congress called a halt to the project and similar kinds of DOD sponsored social and political research. The demise of the project had major policy implications. First it led to a detailed congressional inquiry about the feasibility of establishing: (1) a National Social Science Foundation (like the National Science Foundation but to support social sciences) and (2) a social indicators advisory mechanism in the White House. It also led to creation of a foreign affairs research coordinating mechanism in the State Department and forced cutbacks in the level of military support for social and political research so that in 1986, in terms of constant 1982 dollars, DOD funding for social sciences research is about 73 percent less than it was in 1966.[108] See table III.2.

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[107] For instance, according to William Rosenau: M.I.T. professors at the Draper Laboratory, Columbia professors at the Riverside Research Institute, Johns Hopkins professors at the Johns Hopkins Applied Physics Laboratory. (Rosenau, William. The Warriors of Academe. Inquiry (San Francisco), v. 5, Feb. 15, 1982: 413-14.)

TABLE III.C.—DOD FUNDING OF SOCIAL SCIENCES RESEARCH

[Dollars in thousands]

| Fiscal year | Amount | Fiscal year | Amount |
|---|---|---|---|
| 1961 | $215 | 1974 | $9,330 |
| 1962 | 203 | 1975 | 5,536 |
| 1963 | 3,808 | 1976 | 5,213 |
| 1964 | 1,046 | 1977 | 3,555 |
| 1965 | 4,886 | 1978 | 5,933 |
| 1966 | 8,437 | 1979 | 8,442 |
|  | *(24,286) | 1980 | 5,120 |
| 1967 | 8,912 | 1981 | 4,720 |
| 1968 | 6,074 | 1982 | 4,845 |
| 1969 | 7,717 | 1983 | 7,140 |
| 1970 | 5,123 | 1984 | 3,949 |
| 1971 | 6,133 | 1986 | 7,445 |
| 1972 | 8,109 |  | *(6,458) |
| 1973 | 6,800 |  |  |

* Constant 1982 dollars. Deflator factors provided by NSF.

### 3. RELEVANCY REQUIREMENTS; MANSFIELD AMENDMENT

Budgetary pressures evident during this time also precipitated increased concern about whether federally supported basic research yielded practical results. "Spokesmen for the scientific community had been making claims for practical results flowing from basic research, yet these claims were never systematically substantiated." [109] From World War II until the end of the 1960s, the Defense Department had spent almost 100 billion dollars on R and D. To answer questions about the practical applications of research it commissioned a study, called Project Hindsight, which looked retrospectively at the origins—going back twenty years—of major weapons systems. "Only nine percent of the events were classified as scientific [as opposed to technological in origin], with only 0.3 percent (or two events) representing basic research." [110] Stine reports that

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[108] See, for example, Congressional Response to Project Camelot, In U.S. Congress. House, Committee on Science and Technology. Subcommittee on Science, Research, and Technology. Technical Information for Congress. Report, prepared by the Senior Specialists and Science Policy Research Divisions, Congressional Research Service, Library of Congress. Washington, July 1979, third ed. (Committee print), p. 145–179.

[109] A History of Science Policy in the United States, 1940–1985, op. cit., p. 59.

[110] Sherwin, Chalmers W. and Raymond S. Isenson. First Interim Report on Project Hindsight. Washington, Office of the Director of Defense Research and Engineering, 1966; Chalmers

Continued

"*Hindsight's* conclusions that technological achievements stemmed primarily from mission-oriented engineering research and development provoked immediate and angry reactions." [111] The study was challenged for its methodological flaws, but nevertheless it was ". . . perceived as a considerable threat to the science policy establishment" because since the Bush report Federal support of basic research had been justified on the grounds that it " . . . was the fountain from which technological progress flowed. . . ." [112] The National Science Foundation then supported a study called Project TRACES which came to a conclusion opposite from that of the DOD study, ". . . that basic research conducted at the Nation's universities was the principial factor in the development of important technologies. It followed, therefore, that the Federal Government should continue its support of undirected research." [113] The debate was not resolved, but it had a visible policy effect according to Dr. Stine: "The support of undirected research by Federal mission-oriented agencies began to decrease, especially within the armed services." [114]

Congressional reaction to campus protests, Project Camelot, and relevancy studies resulted in passage in 1970 of the so-called "Mansfield Amendment", that is, section 203 of the FY 1970 Military Authorization Act (Sec. 203 of P.L. 91-121). The amendment read:

> None of the funds authorized to be appropriated by this Act may be used to carry out any research project or study unless such a project or study has a direct or apparent relationship to a specific military function or operation.

Thus this amendment ". . . sought to curtail the Department of Defense from supporting general, nonmilitary-related basic research," [115] on the grounds that a military department should not fund basic research which is not relevant for a particular application, and that other agencies should sponsor basic research that DOD might have supported.[116] "As a result of the Mansfield amendment, the Department of Defense reviewed some 6,600 of its currently funded research projects, and determined that roughly

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W. Sherwin and Raymond S. Isenson. Project Hindsight: A Defense Department Study of the Utility of Research. Science, v. 156, June 23, 1967: 1571-1577, and Raymond S. Isenson, Project Hindsight Final Report. Washington, Office of the Director of Defense Research and Engineering, 1969. As cited in Stine, History of Science Policy in the United States, 1940-1985, op. cit., p. 59.

[111] History of Science Policy in the United States, 1940-1985, op. cit., p. 60.

[112] Ibid., p. 60.

[113] Ibid.

[114] Ibid.

[115] Ibid., p. 62.

[116] According to Brooks: In the words of Senator Mansfield, 'Since the end of World War II, the government's contribution to research, development, and their supporting facilities has reached nearly $200 billion. Where and by whom that money was spent has determined not only the science policy of this nation but the entire emphasis in science education and training. During this time well over half of the government's contribution to science has been channeled through the Department of Defense. It must be clearly understood that most of this money purchased research of the highest quality. However, not nearly so clear is the rationale that dictated that the Department of Defense should be the principal sponsoring agency for much of this vital research. . . . The desirability of such a large role for this mission agency is the basic issue confronting us. (Brooks, op. cit., p. 961-962, citing Mansfield, Senator Mike, Rechanneling the Public Resources for Basic Science through the Civilian Agencies: A New Goal for National Science Policy, Statement to the House Committee on Science and Astronautics, Subcommittee on Science, Research and Development, Aug. 11, 1970.)

four percent . . . did not meet the relevancy test." [117] The next year this language was modified to give the Secretary of Defense broad latitude to determine whether a project was relevant. Specifically section 204 of P.L. 91-441 said:

> None of the funds authorized to be appropriated to the Department of Defense by this or any other act may be used to finance any research project or study unless such project or study has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation.

Most observers concur that the modified Mansfield amendment has had long-term restrictive effects on national science policy and caused all agencies, not only the Department of Defense, to be more cautious in supporting basic research and, in effect, has curtailed the support of some kinds basic research in universities by mission-oriented Federal agencies that might have been supported in the absence of the Mansfield amendment.[118] On this point the Department of Defense concluded:

> Although the wording of the amendment was changed . . . [in 1971] . . ., to recognize the need for DOD to support fundamental research, some residual effects of the amendment continued for several years and in effect caused the DOD effort to tend toward short-term research performed by universities. However, this trend has now been reversed, and the DOD and the academic sector have restored their productive partnership in pursuit of long-range fundamental ventures in scientific inquiry.[119]

## M. Recent Events

Writing in 1977, York and Greb concluded that from Sputnik until 1977, no major changes occurred in the structure of military R&D management despite the occurrence of major events comparable in scope to Sputnik, an event which produced several reorganizations. The external events they listed included:

> The Bay of Pigs, the orbiting of the first Soviet cosmonaut, the Cuban missile crisis, the acceleration of the Indochina war in 1965, and the U.S. withdrawal from Vietnam and final defeat in the 1970s.[120]

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[117] A History of Science Policy in the United States, 1940-1985, op. cit., p. 62., citing Bates, Dorothy. The History of Federal Science Policy, 1787-1970 in U.S. Congress. House Committee on Science and Astronautics, Toward a Science Policy for the United States. 91st Cong., 2nd Sess. Washington, U.S. Govt. Print. Off., 1970, p. 111-112.

[118] See, for example, A History of Science Policy in the United States, 1940-1985, op. cit., p. 63. See also: Nichols, Rodney W. Prepared Statement before the Task Force on Science Policy, Hearings on Science in the Mission Agencies, Committee on Science and Technology, U.S. Congress. House, Oct. 23, 185. See also: U.S. National Science Board. Basic Research in the Mission Agencies. Agency Perspectives on the Conduct and Support of Basic Research. Report. 1978. Washington, U.S. Govt. Print. Off., 1978, p. 261.

[119] U.S. Dept. of Defense. Basic Research Program, 1984, p. 4. See also: Bates, Dorothy M. Relevance Requirements for Research Supported by the Department of Defense in P.L. 91-121, sec. 203, and P.L. 91-461, sec. 204: Effects on Federal Support of Basic Research. By Dorothy M. Bates, Congressional Research Service, Typed Report, Mar. 31, 1978, 30 p.

[120] York and Greb, op. cit., p. 25.

After 1977, the major defense issue which appears to have affected the scope and substance of defense R&D programs and their management was renewed tension between the Soviet Union and the United States, peaking with the Soviet incursions into Poland and Afghanistan, which resulted, in part, in an acceleration of funding for military R&D late in the Carter Administration. This is demonstrated by trends in funding for defense R and D, which increased only 20 percent from 1971 to 1975, but 45 percent from 1976 to 1980, during the Carter presidency. Part of this increase may have been due to inflation.

This was followed by an even greater emphasis on military R&D during the Reagan Administration, resulting from criticisms of lags in U.S. national security, and President Reagan's program for research into, and eventual deployment of a Strategic Defense Initiative (SDI) system, often called "Star Wars." Funding for defense R&D increased 88 percent from 1981 to 1985, significantly more during the first Reagan Administration than during the two previous presidencies. This increased emphasis on defense buildup and defense R&D was accompanied by accelerated efforts within the DOD to enhance research relationships with the research performing community, especially universities. This is reflected in several initiatives taken by the Pentagon, including such actions as creation of the DOD-University Forum to debate and discuss research relationships and factors affecting the production of knowledge, the University Research Instrumentation Initiative, expansion of DOD-funded graduate fellowship programs in the sciences, and expansion of ROTC programs. (For additional details, see chapter V.) The inception of the Strategic Defense Initiative (SDI) program and the rapid acceleration of research funding for SDI, from $1.4 billion in fiscal year 1985 to $3.21 billion in fiscal year 1987, was accompanied by an emphasis on widening the number of universities available to do SDI research, to include institutions that historically have done little research for the Defense Department. This effort was made in part to find additional research performers to counter criticisms of SDI and SDI research emanating from some individual researchers associated with large university performers of military research. These and related issues are discussed in chapter V.

Changes have been made in the DOD R&D management structure. Drs. York and Greb reported in 1977, that "Since 1960, two countervailing influences, each of which might have resulted in substantial changes in the authority and status of the Office of the Director of Defense Research and Engineering, have, in effect, cancelled each other out." [121] On the one hand President Nixon's Blue Ribbon Panel on Defense Reorganization recommended "dissolution of the DDR&E post." But, on the other hand, this did not occur and eventually the DDR&E office was expanded with the additional of a new test and evaluation function.

The authority of DDR&E may have been weakened in actual practice from time to time since technical experts have occasionally served in other high level posts within the Department, such as

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[121] Ibid.

". . . Secretary of the Air Force Brown, Deputy Secretary of Defense Packard, and Secretary of Defense Schlesinger." [122]

As a countervailing influence, York and Greb noted that "PSAC, which provided the only external competition [to the DDR&E] for authority over military R&D by a group possessing high technical competence, has been abolished and no comparable body has taken its place." They concluded that "the net result of these events and trends [up to 1977] is that both the functions and the authority of the Director of Defense Research and Engineering have remained constant over almost two decades." [123] On October 21, 1977, the position of Director of Defense Research and Engineering was redesignated as the Under Secretary of Defense for Research and Engineering, with the enactment of P.L. 95-140. This office was terminated and DDR&E was recreated in 1986. See the end of this section below.

Since 1977 several events have occurred to influence military research. In 1978, a report requested by the Presidential Office of Science and Technology Policy, called the Galt report,[124] recommended increased funding for DOD-sponsored basic research. The report has also been credited with broadening the concept of relevance of most kinds of research to military needs, thereby minimizing the lingering restrictive effects of the modified Mansfield amendment, and with calling for closer relationships between the scientific community and the universities on the one hand, and the Department of Defense on the other.[125] Shortly after the release of the Galt report, it was announced that Harold Brown, the former president of the California Institute of Technology, and President Carter's Secretary of Defense, made a commitment to increase military funding for basic research by 10 percent per annum in real dollars for the next decade. Dickson described the reaction as follows:

> With the Galt report in their hands, Brown and [Presidential science advisor Frank Press] leaned heavily on the Office of Management and Budget and persuaded it to approve an extra $100 million in DOD funding for basic science in the administration's budget request to Congress for 1979. Congress added its own support to these initiatives, which were enthusiastically endorsed by the House Armed Services Comittee in its authorization report for the fiscal year 1979 budget. The result was a 30 percent increase in DOD basic research between 1977 and 1980—and a 70 percent increase in DOD support for university research over the same time period.[126]

Military funding for R&D at universities and colleges and associated FFRDCs increased 148 percent from 1980 to 1987, est. At some schools, prohibitions against doing classified work on campus were lifted. According to Dickson:

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[122] Ibid., p. 25-26.

[123] Ibid., p. 26.

[124] The Galt Report is Report of the Working Group on Basic Research in the Department of Defense. Executive Office of the President. Office of Science and Technology Policy, June 22, 1978.

[125] Dickson, op. cit., pp. 126-127, citing Science Advisor's Panel on Basic Research in Department of Defense. Basic Research in the Department of Defense. Washington, D.C., Office of Science and Technology Policy, June 22, 1978.

[126] Dickson, op. cit., p. 127.

> Even some of those who had been among the Pentagon's critics in the 1960s seemed to have had a change of heart. Alex Rich, professor of biology at MIT and one of the signatories of a 1969 faculty statement deploring the misuses of sciences by the military, explained that although the Vietnam War had been a "moral abomination," the U.S. had since entered a new era. "The fact is we need a vigorous science program in our universities, and the Defense Department has a special responsibility," said Rich. "We used to get Naval support for biology at MIT; we'd like to get that again." Several institutions, such as Rutgers University, revised rules passed eagerly by faculty members during the war so that they could once again accept classified research contracts.[127]

There was considerable interest during the first half of the 1980s in ensuring that the university infrastructure and broader U.S. technology base were sufficiently capable of providing the military with the knowledge needed to meet national security needs. The DOD-University Forum, created in 1983, recommended creating new interfaces between the affected communities and enhancing programs to strengthen the Nation's scientific and technical resources.[128] The Defense Science Board issued a report in 1980 on the technology base, which endorsed building an industrial infrastructure and university base for defense preparedness.[129] David Dickson reported that legislation was enacted in 1981 "with the active help of the House Armed Services Committee . . ." that shifted ". . . from a procurement to a grants basis for defense research, a move that reduced the amount of form-filling required of university scientists receiving Pentagon funds—but a move that reduced as well the constraints under which they were required to work." There apparently was considerable congressional debate about the merits of this legislation and its possible negative impacts, that is ". . . allowing the military to use grants rather than contracts for research projects could open the door to 'millions of dollars of waste.' "[130]

In 1983, Congress enacted legislation which widened the competitive basis of R&D funding, with the enactment of P.L. 98–72, an act to improve small business access to Federal procurement information, informally called the "Competition in Contracting Act." Under the Act, an agency solicitation for R&D cannot be issued until thirty days after a notice of procurement action is published in the *Commerce Business Daily.* Exemptions from competitive contracting requirements are allowed if the procurement results from acceptance of a proposal pursuant to the Small Business Innovation Development Act of 1982 or from research which requires a unique or innovative research method and if publication of any related unsolicited proposal would compromise the originality of the proposed research. There are also some exemptions for defense related work. Nevertheless, there have been compliants that this statute may slow up the procurement of defense research and, therfore, may be detrimental to it.

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[127] Dickson, op. cit., p. 129.

[128] Report of the DOD-University Forum, Dec. 1984. Washington, U.S. Govt. Print. Off., 1984, 48 p., plus appendix.

[129] Dickson, op. cit., pp. 130–131.

[130] Dickson, op. cit., citing Congressional Record, July 10, 1981, H4209.

Congressional committees have expressed considerable interest in military research production capabilities, as is evidenced by language included in several recent authorizations reports of the House and Senate Armed Services Committees, which call for DOD to evaluate issues relating to technology base and university laboratory needs. These actions resulted in the preparation of at least two special reports dealing with capabilities to produce scientific and technical information.[131] The substance of some of the programs developed by the Pentagon to augment research production coincided with some of the recommendations made in these reports. These programs included: the university research initiative, enlarged educational and training programs, increased funding for laboratory equipment.

There were several organizational and management changes that occurred during the 1980s that affect military research. One is the creation of the Strategic Defense Initiative Organization, with its program of innovative technology, that is responsible for the support of basic research related to the SDI.

In addition, several presidentially endorsed commission reports have been released which evaluated aspects of the funding and organization of R&D production in the Defense Department and the services. The Grace Commission reported on improving efficiency in government made several recommendations affecting DOD research and development processes, including those affecting laboratories, salaries for scientists and engineers (see chapter VI in this report) and organization of the office of the Under Secretary of Defense for Research and Engineering. The President's Blue Ribbon Commission on Defense Management, the Packard Commission, recommended, among other things that DARPA be given more responsibilities for prototype development, and that an Under Secretary for Acquisition be created to establish research and engineering policy for the Department. Both of these recommendations have been adopted. For additional information, see chapter IV of this study.

## N. CONCLUDING COMMENTS

The military has had a strong influence on the course of the Nation's history generally. It is also acknowledged that military activities had a salutary effect on the development of U.S. science policy and research policy. Historically, the most persuasive argument for Federal support for science and technology has been military necessity; and Federal support for military research has shaped enduring Federal programs and policies in the "Federal

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[131] The Department of Defense Report on the Technology Base and Support of University Research for the Committees on Armed Services, U.S. Congress, Mar. 1, 1985, 83 p. and the Department of Defense Report on Selected University Laboratory Needs in Support of National Security. Prepared for the Subcommittee on Research and Development of the Committee on Armed Services of the United States House of Representatives. Apr. 25, 1985, 63 p.

Government-science relationship." Federal support of university research, and of basic research in the National Science Foundation are two principal examples. Since the latter half of the 1970s, and especially since the advent of the Reagan Administration in 1981, the military has begun to absorb U.S. science and technology resources at a level comparable to that in the Eisenhower era. Military R&D funding absorbs about 70 percent of the Federal R&D budget. Increasing offers are being made to industry and the universities to expand their military research agendas.

These trends again raise questions, as they did in the past, about the balance between military and civilian funding. Questions remain about the Nation's priorities for R&D funding and about whether the DOD needs to expand its activities to strengthen the scientific and technical infrastructure from which it expects so much.

# CHAPTER IV

## MILITARY RESEARCH FUNDING TRENDS, PROCESSES, AND ORGANIZATIONS*

This chapter summarizes major DOD research funding trends and defines the performers; describes the organization of research management structures, priority-setting mechanisms (including discussion of the U.S.-Soviet balance in science and technology and weapons technology), and procedures the military uses to fund research and apply results. The organizations surveyed are the Army, the Navy, the Air Force, the Defense Advanced Research Projects Agency, and the Office of the Under Secretary of Research and Engineering; assesses the similarities and differences in funding mechanisms and review procedures used by DOD and by other Federal agencies, and identifies unresolved issues regarding procurement of military research. It also summarizes major issues regarding the efficiency and effectiveness of military research processes and policies, including questions about interservice rivalry, centralized vs. decentralized research management, linking research investment decisions to military needs, long-range research priorities, and "high-technology" vs. "low-technology" efforts.

This chapter deals mostly with events and funding trends that occurred prior to the late 1986 reorganization of the Department of Defense which terminated the office of Under Secretary for Research and Engineering and transferred most of its functions to the office of the Under Secretary for Acquisition. Except for the creation of an Office of Director of Defense Research and Engineering, it appears that there have not been changes in many of the subsidiary organizations and functions discussed. When appropriate, the chapter identifies the implications of the reorganization for research and development decisionmaking.

### A. DEFINITIONS AND TRENDS

At the outset it is necessary to define the terms that are used in this chapter. The budget term "RDT&E" used in DOD budget documents is an abbreviation for the defense activities constituting research, development, test, and evaluation. It is often disaggregated two ways. First, in DOD congressional budget documents, RDT&E activities are divided into six separate activities. These six categories are:

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*Prepared by Genevieve J. Knezo, Specialist in Science and Technology, Science Policy Research Division.

I. Technology base;
II. Advanced technology development;
III. Strategic programs;
IV. Tactical programs;
V. Intelligence and communications; and
VI. Defense wide mission support.

In the fiscal year 1988 budget request, about 31 percent of the RDT&E category serves tactical programs, the largest category; the other activities received smaller percentages of the RDT&E total. See Table IV A.

### 1. CATEGORIES OF RDT&E

The second taxonomy for DOD RDT&E funding is based on functional categories. The DOD does not routinely employ the categories of "basic research", "applied research", and "development" in its budgeting and program management. Instead, it used a series of six RDT&E functional categories numbered 6.1 to 6.6. These are defined by DOD as follows:[1]

> *6.1 Research.* Includes scientific study and experimentation directed toward increasing knowledge and understanding in those fields of the physical, engineering, environmental, biological-medical, and behavioral-social sciences related to long-term national security needs. It provides fundamental knowledge for the solution of identified military problems. It also provides part of the base for subsequent exploratory and advanced developments in the defense-related technologies and of new or improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support.[2]
>
> *6.2 Exploratory Development.* Includes all effort directed toward the solution of specific military problems, short of major development projects. This type of effort may vary from fairly fundamental applied research to quite sophisticated breadboard hardware, study programming and planning effort. It would thus include studies, investigations and minor development effort. The dominant characteristic of this category of effort is that it be pointed toward specific military problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters. Program control of the Exploratory Development elements will normally be exercised by general level of effort.
>
> *6.3 Advanced Development.* Includes all projects which have moved into the development of hardware for experimental or operational test. It is characterized by line item projects, and program control is exercised on a project

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[1] DOD INST 7720.16 (OPNAV 3910.16), enclosure (3), p. 2-7, 2-8.

[2] Successful 6.1 projects often lead to 6.2 work to explore the uses of proven concepts in military applications. One frequently-cited example is the development of the laser, which received DOD support from the time of its invention and now has many proven civilian and military applications. The research of Nicholas Bloembergen, who shared the 1981 Nobel Prize in physics for research leading to the laser, was supported by the DOD Joint Services Electronics Program.

basis. A further descriptive characteristic lies in the design of such items being directed toward hardware for test or experimentation as opposed to items designed and engineered for eventual Service use.

*6.4 Engineering Development.* Includes all those development programs being engineered for Service use but which have not yet been approved for procurement or operation. This area is characterized by major line item projects and program control by review of individual projects.

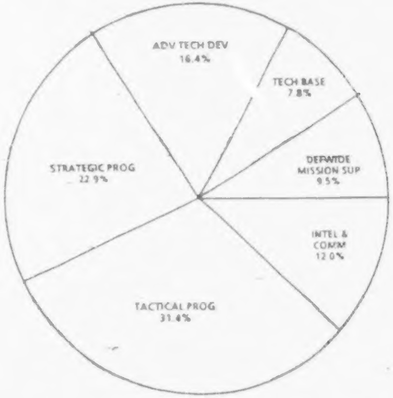
*6.5 Management and Support.* Includes research and development effort directed toward support of installations or operations required for general research and development use. Included would be test ranges, military construction, maintenance support of laboratories, operations and maintenance of test aircraft and ships, and studies and analyses in support of the R&D program. Costs of laboratory personnel, either in-house or contract-operated, would be assigned to appropriate projects or as a line item in the Research, Exploratory Development, or Advanced Development Program areas, as appropriate. Military Construction costs directly related to a major development program will be included in the appropriate element.

## TABLE IV-A*

### RDT&E BY BUDGET ACTIVITY
TOA ($ MILLIONS)
FY 1988 / 1989 BUDGET ESTIMATE

| | FY 1985 | % | FY 1986 | % | FY 1987 | % | FY 1988 | % | FY 1989 | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Technology Base | 3120.7 | 10.1 | 3232.4 | 9.6 | 3233.3 | 8.9 | 3420.6 | 7.8 | 3643.3 | 8.2 |
| Advanced Tech Dev | 2750.6 | 8.9 | 4066.8 | 12.1 | 4930.1 | 13.6 | 7163.2 | 16.4 | 8477.8 | 19.2 |
| Strategic Prog | 8169.0 | 26.5 | 7509.0 | 22.3 | 8124.7 | 22.4 | 9990.0 | 22.9 | 9222.9 | 20.9 |
| Tactical Prog | 9062.2 | 29.4 | 10265.8 | 30.5 | 10998.1 | 30.3 | 13726.6 | 31.4 | 13826.5 | 31.3 |
| Intel & Comm | 3953.0 | 12.8 | 4525.1 | 13.4 | 4922.8 | 13.6 | 5262.1 | 12.0 | 4842.0 | 11.0 |
| Defwide Mission Sup | 3814.0 | 12.3 | 4077.0 | 12.1 | 4043.0 | 11.2 | 4156.4 | 9.5 | 4190.1 | 9.4 |
| TOTAL RDT&E | 30869.5 | 100.0 | 33676.1 | 100.0 | 36252.0 | 100.0 | 43718.9 | 100.0 | 44202.6 | 100.0 |

FY 1988



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*Sources: The FY1987 DOD Program for R&D. Statement by the Under Secretary of Defense, Research and Engineering, p. A-4 and Statement by Richard P. Godwin, Under Secretary of Defense for Acquisition before the Research and Development Subcommittee, House Armed Services Committee, 100th Cong., 1st session. March 4, 1987.

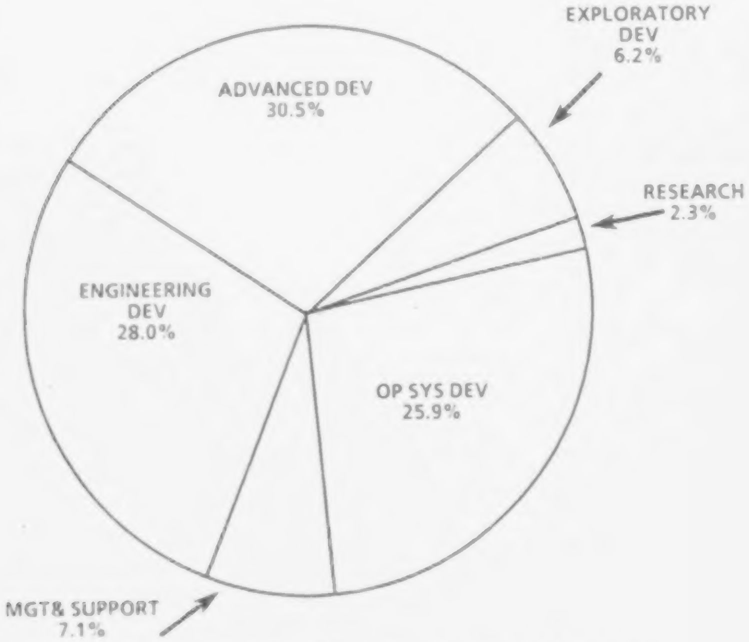
*6.6 Operational Systems Development.* Includes research and development effort directed toward development, engineering and test of systems, support programs, vehicles and weapons that have been approved for production and Service employment. 6.6 is not an official category as are 6.1–6.5, but is a term used for convenience in reference and discussion. Thus, no program element will exist numbered 6.6. . . . All items in this area are major line item projects which appear as RDT&E costs of weapons systems elements in other programs. Program control will thus be exercised by review of the individual research and development effort in each Weapon System Element.

Activities in categories 6.3 to 6.6 typically receive the bulk of RDT&E funding, (91.5 percent in fiscal year 1987 estimated). See table IV B.

Table IV 3

# RDT&E BY R&D CATEGORY *
TOA ($ MILLIONS)
FY 1987 BUDGET ESTIMATE

| | | | | | | Request | |
|---|---|---|---|---|---|---|---|
| | | FY 1985 | % | FY 1986 | % | FY 1987 | % |
| 6.1 | Research | 852.3 | 2.8 | 1024.2 | 2.9 | 985.8 | 2.3 |
| 6.2 | Explor Dev | 2268.4 | 7.3 | 2424.9 | 6.8 | 2599.4 | 6.2 |
| 6.3 | Adv Dev | 6743.0 | 21.8 | 9875.3 | 27.8 | 12775.8 | 30.5 |
| 6.4 | Engin Dev | 10490.8 | 34.0 | 10149.3 | 28.6 | 11717.5 | 28.0 |
| 6.5 | Mgt & Sup | 2516.6 | 8.2 | 2611.1 | 7.4 | 2972.8 | 7.1 |
| 6.6 | Op Sys Dev | 7998.4 | 25.9 | 9382.0 | 26.5 | 10878.5 | 25.9 |
| | TOTAL RDT&E | 30869.5 | 100.0 | 35466.7 | 100.0 | 41929.9 | 100.0 |



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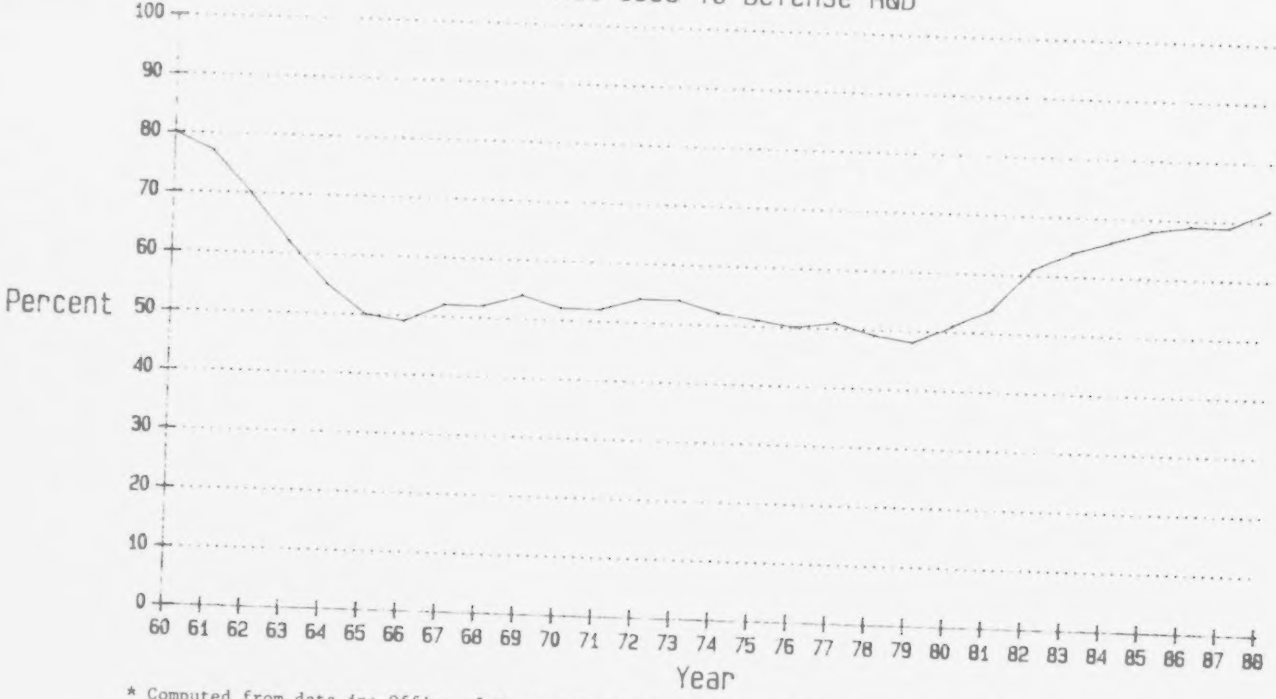
* The FY 1987 DOD Program for R&D. Statement by the Under Secretary of Defense for Research and Engineering, p. A-5.

Table IV C *

Percent of Total Federal R&D
That Goes To Defense R&D



* Computed from data in: Office of Management and Budget. Special Analysis J, 1988 Budget Request.

## 2. TECHNOLOGY BASE ACTIVITIES

The budget activity "technology base" consists of funds in categories 6.1 and 6.2. The technology base funding request for fiscal year 1988 was $3.4 billion, and constitutes about 7.8 percent of the RDT&E budget.[3] DOD views the 6.1 program "as the source of its future technology."[4] The 6.1 budget contains two basic elements. One is Defense Research Science, which comprises 92 percent of the program. It includes "all the extramural efforts and most of the 6.1 tasks performed in the in-house laboratories."[5] The second component is allocated to the In-House Laboratory Independent Research program, which gives laboratory directors discretionary funding or "venture capital" "to enable them to take immediate advantage of technological opportunities and to maintain a research base in the DOD laboratories."[6]

The Department of Defense funds research in the fields of:

—physics, radiation sciences, astronomy, astrophysics;
—electronics;
—chemistry;
—mathematics and computer sciences;
—mechanics and energy conversion;
—materials;
—aeronautical sciences;
—oceanography;
—terrestrial science;
—atmospheric sciences;
—biological and medical sciences; and
—behavioral sciences.[7]

Work in these fields has applications in such areas as: space technology, computer sciences, electronics, surveillance, command and control, communications, propulsion, aerodynamics, night vision, chemical and biological defense, materials and structures, medical and life sciences.[8]

The DOD claims that research accomplishments are transferred or quickly passed on to the military research community and applications program managers:

> Because of the vertical R&D structure [the technical directors of the military service organizations are responsible for affecting and facilitating technology transfer under the guidance and review of the Director of Research and Laboratory Management] and the fact that many of the in-house organizations doing 6.1 research are also engaged in 6.2 and 6.3 work, the time involved in applying the appropriate results of the 6.1 program can be shortened.[9]

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[3] Chart 6. In Statement by Richard P. Godwin, Under Secretary of Defense for Acquisition before the Research and Development Subcommittee, House Armed Services Committee, First Session, 100th Congress, March 4, 1987.

[4] Department of Defense. Basic Research Program, Sept. 1985. Washington, U.S. Govt. Print. Off., 1985. p. 7.

[5] Ibid., p. 7.

[6] Ibid., p. 7.

[7] Carter, Colonel Donald I. The Department of Defense Statement on Science in the Mission Agencies and Federal Laboratories. Before the Task Force on Science Policy of the Committee on Science and Technology of the U.S. House of Representatives, Oct. 2, 1985. p. 7.

[8] Ibid., p. 6.

[9] Ibid., p. 8.

The terms "Science and Technology Program" is also sometimes used to characterize a portion of the DOD RDT&E budget. This refers to technology base plus "advanced technology development" (budget category 6.3A).[10] Thus, DOD "science and technology work" is the sum of 6.1, 6.2, and 6.3A.

The fact that DOD budget categories are only approximately equivalent to the usual R&D categories employed by the National Science Foundation (NSF) is illustrated by the fact that all of the funding for the Strategic Defense Initiative (SDI) is included in budget category 6.3 even though it includes activities otherwise categorizable as 6.1 through 6.3. This use of the term "research" in the SDI program, probably to demonstrate ABM treaty compliance, is not the same as NSF "research." In fact it is generally acknowledged that only about 10 percent of the Strategic Defense Initiative Program (SDI) is basic and applied research (sometimes referred to as "innovative science and technology" by the SDI office).

This report concentrates on technology base funding with some emphasis on 6.1, or basic research. However, work done in categories 6.2 to 6.6 is addressed as well.

NSF's data are used for the most part in this chapter because they are available historically for the years being studied, internally consistent with data collected for other agencies, and roughly equivalent to the DOD terms: the DOD term 6.1 with the NSF term 'basic research," the DOD term 6.2 with the NSF category of "applied research," and the DOD terms 6.3 to 6.6 with the NSF category of "development". In addition, the total dollar amount reported in NSF documents for DOD R&D is approximately equivalent to the funding levels reported in DOD documents for RDT&E for the corresponding years.[11]

According to OMB data, defense related research and development (R&D) obligations—funded by the Departments of Defense (DOD) and Energy (DOE)—will total about $39.9 billion, estimated for the fiscal year 1987, and constitute about 69 percent of all funds that the Government will obligate for R&D in fiscal year 1987.[12] DOD funds about 90 percent of the total amount obligated for defense-related R&D and DOE the remainder, principally for nuclear weapons research. The obligation for defense related research represents about one-third of total national (public and private) spending for R&D. Typically, DOD outlays for RDT&E constitute about 10 percent of annual outlays for all national defense purposes.

### 3. FUNDING FOR RDT&E ACCELERATED SIGNIFICANTLY IN THE 1980S

During the period fiscal years 1965 to 1980, about 50 percent of Federal R&D funding annually went to the defense sector each year and the greatest outlay for defense R&D (by the Department of Defense and the Department of Energy) was about $18 billion, in

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[10] Definition supplied by Dr. Leo Young, Director for Research and Technical Information, (USDRE, DOD, 1986.)

[11] Some observers argue that the term RDT&E encompasses a broader scope of activities than is normally included in definitions of civilian R&D and that as a result the amount of funding reported by DOD is exaggerated. Despite this argument, both NSF and OMB include all DOD RDT&E funds, including Testing and Evaluation, within the category of "R&D."

[12] Calculated from table J-10. In Special Analysis J. Research and Development. U.S. Office of Management and Budget. Special Analyses of the Budget of the U.S. Government. Fiscal Year 1988.

1980 (in constant 1982 dollars). DOD outlays for RDT&E constituted about $16.1 billion. The amount of federally funded R&D that goes for defense work has been significantly increased—both in absolute dollars and in relation to civilian R&D funding—since 1981. See table IV D and IV E. It is estimated that in the fiscal year 1987, defense-related research and development outlays will be $31.7 billion in constant 1982 dollars. This represents 69 percent of the Federal R&D budget. DOD outlays for R&D will constitute about $29.7 billion, some 64 percent of outlays estimated for Federal R&D.[13]

Despite these increases, the proportion of Federal R&D that goes to defense today is still below the high levels of the 1950s and early 1960s, when over 80 percent of Federal R&D funding went to support defense related work.

In terms of constant 1982 dollars, DOD's RDT&E funding during the decade of the 1970s averaged about 30 percent less than the average in the decade of the 1960s. NSF reports that "despite far-ranging program activities, total DOD R&D growth in the seventies was still insufficient to stay ahead of inflation in most years. In fiscal year 1980, even though the DOD R&D total showed real growth over the previous year, it was still below the 1970 total in constant dollars." [14] However, a dramatic upsurge in funding, in constant 1982 dollars, began in 1982, when DOD R&D outlays totaled $18 billion (about the same level as 1970 in constant 1982 dollars). Outlays in fiscal year 1986 are estimated at $29 billion in constant 1982 dollars (about $33 billion in current dollars), an increase of 58 percent since fiscal year 1982.[15]

### 4. RELATIVE DECLINE IN FUNDING FOR RESEARCH

Most of this funding increase has gone to development, or more properly the DT&E spectrum of DOD RDT&E, rather than to research. The trend shows a decrease in funding as a percentage of total DOD obligational authority and RDT&E funding for categories 6.1 and 6.2, which constitute the DOD area of "technology base." See tables IV D and IV E. The percentage of total RDT&E that funds technology base work has been declining steadily overtime, from a high of about 25 percent of the RDT&E budget in fiscal year 1965 to about 7.8 percent of the RDT&E budget in fiscal year 1988 requested.

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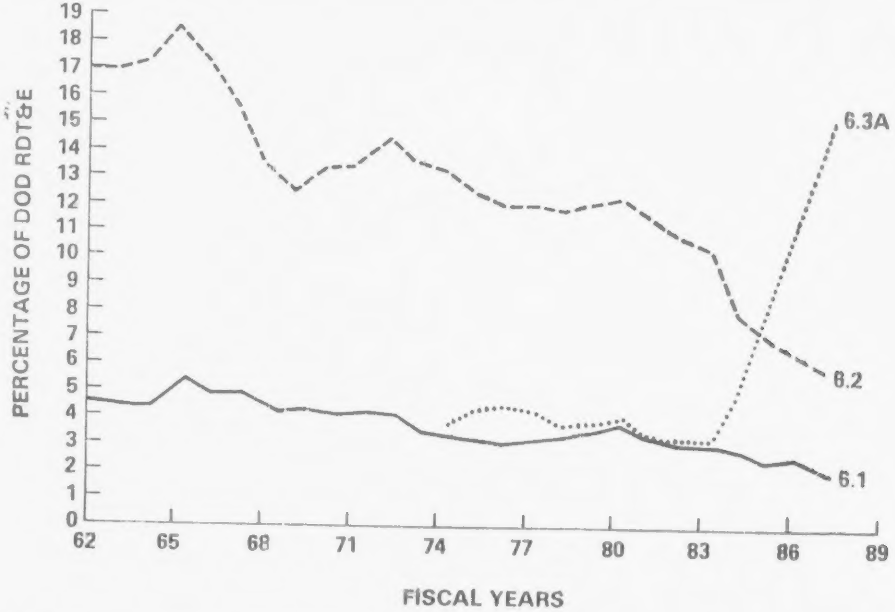
[13] Calculated from table 10.2. in U.S. Office of Management and Budget. Historical Tables. Budget of the U.S. Government. Fiscal Year 1988.

[14] U.S. National Science Foundation. Federal Funds for Research and Development. Fiscal Years 1980, 1981, and 1982. v. XXX. Surveys of Science Resources Services. Final Report. NSF 82-321. Washington, U.S. Govt. Print. Off., 1982. p. 14.

[15] Table 10.2. U.S. Office of Management and Budget. Historical Tables. Budget of the U.S. Government. Fiscal Year 1988.

Table IV D*

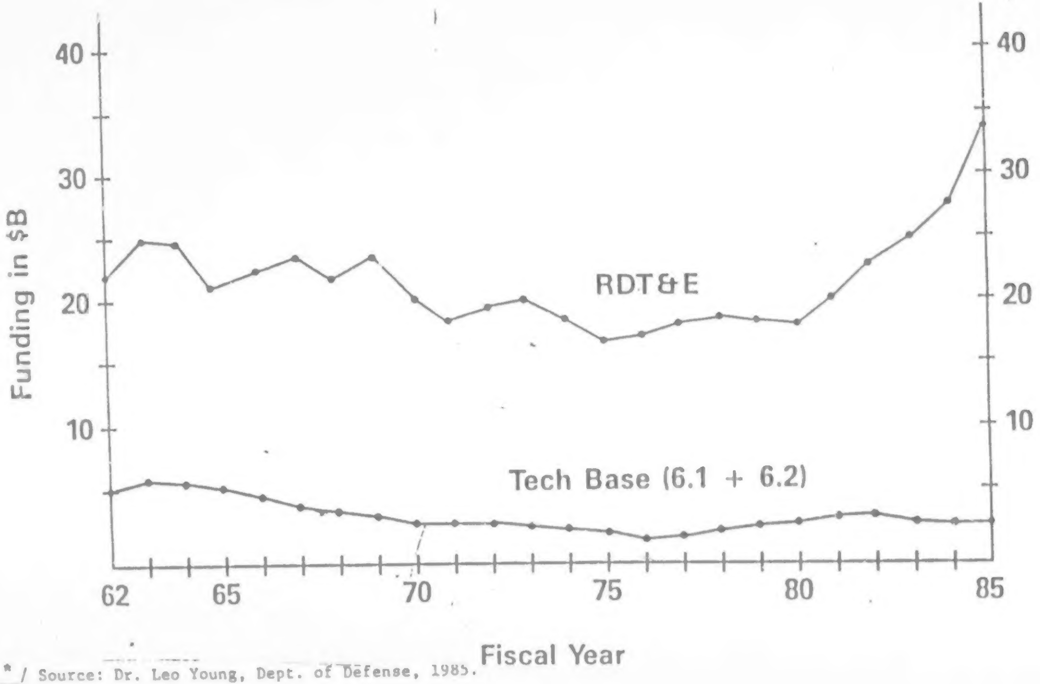
## DOD SCIENCE AND TECHNOLOGY TREND PERCENTAGE OF DOD RDT&E



* Source: Viewgraph package 7-0241. Department of Defense. Basic Research Program. Presented by Dr. Ted G. Berlincourt, Director, Research and Laboratory Management.

Table IV E

## DEFENSE RDT&E AND TECH BASE FUNDING IN FY85 CONSTANT DOLLARS*



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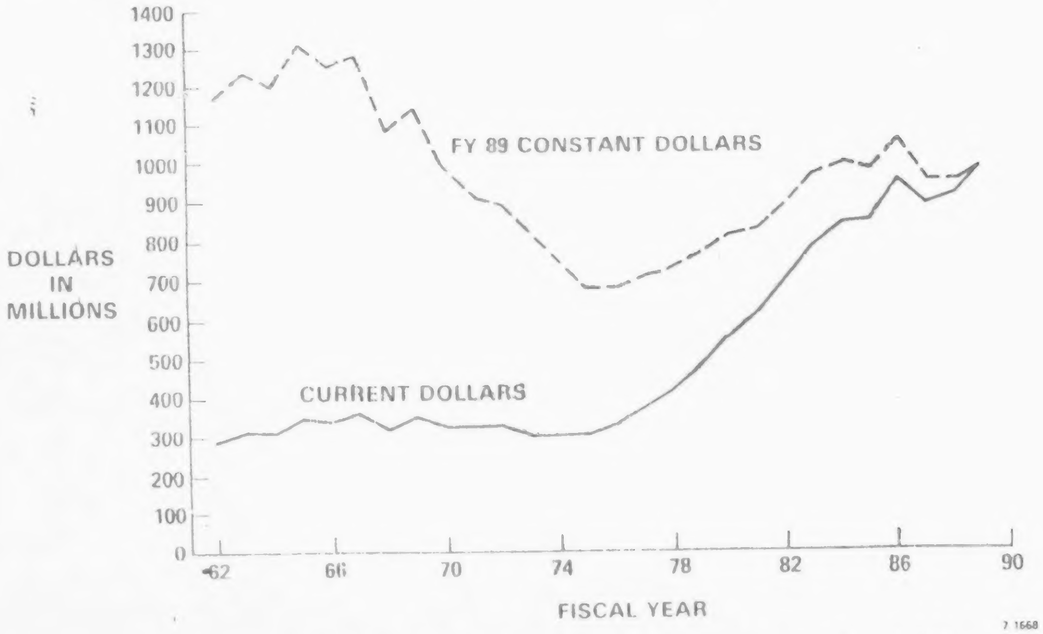
*/ Source: Dr. Leo Young, Dept. of Defense, 1985.

Before the inception of large-scale research programs in civilian agencies, the DOD funded the bulk of all federally funded research. For instance, in the 1950s and early 1960s, the Department of Defense funded on average about 60 percent of federally funded research. This dropped to about 35 percent in the late 1960s (even though dollar amounts for DOD actually increased) following the inception of large research support programs in NASA and NSF. DOD was the largest basic research supporter in the Government until the mid-1960s and today is the third largest single supporter, with 13 percent of the total. "Basic research" (6.1) funding, requested at the level of $918 million for fiscal year 1988 (see figure IV F) accounts for about 2.1 percent of the RDT&E budget, a decrease from the higher percentage levels of the preceding years (averaging about 4.6 percent in the 1960s and about 3.6 percent in the 1970s). See chart IV G. DOD "applied research" funding (6.2 roughly) is about three times more than basic research funding, but its rate of increase has been less than the rate of increase for basic research. DOD generally has been the single largest Federal agency supporter of applied research. In the fiscal year 1985, DOD supported 29 percent of total Federal funding for applied research, a decrease from the 50 percent levels of the 1960s.

Table IV F*

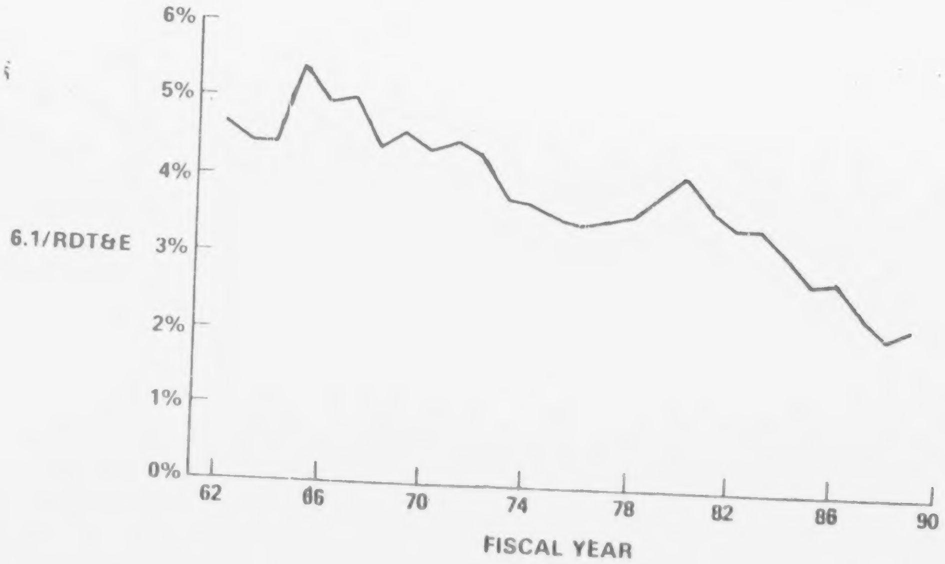
## DoD SCIENCE AND TECHNOLOGY TREND CURRENT AND CONSTANT DOLLARS RESEARCH (6.1)



* Source: Viewgraph package 7-0241. Department of Defense. Basic Research Program. Presented by Dr. Ted G. Berlincourt, Director, Research and Laboratory Management.

Table IV G*

# DoD SCIENCE AND TECHNOLOGY TREND RESEARCH (6.1) RELATIVE TO RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDT&E)



*Source: Viewgraph package 7-0241. Department of Defense. Basic Research Program. Presented by Dr. Ted G. Berlincourt, Director, Research and Laboratory Management.

7 1668

There has been considerable criticism that more basic and long-range defense research is needed.[16]

General Bennie L. Davis, Commander in chief, Strategic Air Command said in 1983:

> This lack of . . . funding creates an ultraconservative attitude in the industrial community and undermines the resource base we need to maintain technological sufficiency—let alone superiority. Because it takes 10 to 20 years to incorporate a new technology in a weapon system, we must establish a real growth trend now to meet the needs of the next century.[17]

There is also a tendency for research to suffer disproportionately larger cuts than other parts of the RDT&E budget, when Congress trims the DOD budget. Notably, all research funding, except SDI funding, was cut about 9 percent to comply with the cuts imposed by the Gramm-Rudman-Hollings deficit reduction act during fiscal year 1986, in order to protect SDI from any funding cuts.

Writing in 1985, Edith W. Martin, former Under Secretary of Defense for Research and Development, called our enhanced funding and priorities for basic research:

> An area needing careful assessment is the Basic Research Program. This program has not received the priority that Congress and the Secretary of Defense intended. Basic Research is important because it is the source of new ideas, science and knowledge vital to maintaining the leverage provided by superior technology. DOD's Basic Research Program is a cooperative enterprise involving universities in-house laboratories, and industry, with aproximately 50 percent of the research budget devoted to university on-campus research. Budgetary support for this vital effort is now minimal, amounting to only 3 percent real growth during recent years. This is a result of budget cuts necessary to balance scarce resources with ongoing program commitments. It has become evident that we can no longer afford to sacrifice basic research, which is the foundation for tomorrow's new technology developments.[18]

Several times in the past, Pentagon officials have announced plans or goals of raising budget levels for research by minimum annual percentage targets. These announcements have had little effect on subsequent budgeting. In 1976, the Defense Science Board called for increases in funding for long-term research. This view was reaffirmed by a 1978 report of the President's Science Advisor reviewing the policies and practices of the DOD (the Galt Committee).[19] Only a small marginal funding increase was made in research. In 1976 "the Secretary of Defense decided that the technology base should have a real growth of 10 percent in basic research and 5 percent in exploratory development. That growth has never materialized." [20] On August 9, 1984, in an effort to compensate for the relative declines in funding for 6.1 and 6.2 research, Defense Secretary Weinberger announced that he would specify an eight percent annual real growth rate in the next budget cycle for 6.1 research and 6.2 exploratory development.[21] While it is estimated that FY 1986 funding for 6.1 research and 6.2 exploratory development exceeded the fiscal year 1985 level by 10 percent, the FY 1987 level exceeded the FY 1986 level by only 4 percent. During hearings held by the Task Force on Science Policy in October 1985, Dr. Robert S. Cooper, former Assistant Secretary of Defense and Director of DARPA, recommended that the Pentagon set aside 10 percent of the DOD R&D budget for basic research support.

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[16] Carey, William D. Defense R and D Priorities. Science, v. 224, May 25, 1984: 821. See also: Gregory, William H. Prognosis for Basic Research. Aviation Week and Space Technology, v. 120, Mar. 26, 1984: 11.

[17] Davis, Bennie L. Some Strategic Common Sense. Astronautics and Aeronautics, v. 21, Sept. 1983: 58.

[18] Martin, Edity W. Managing Science and Technology for the Future. DS2003+, Aug.-Sept. 1985: 55.

[19] Suttle, Jimme. Basic Research From Lewis and Clark to Laser Physics. Defense 82, June 1982: 25.

### 5. RESEARCH PERFORMERS

DOD is the largest Federal agency supporter of R&D for three performers—Federal intramural (that is, "in-house"), industrial firms, and FFRDCs (federally funding research and development centers or Federal contract research centers, which are FFRDCs) administered by nonprofit institutions. For fiscal year 1986, it is estimated that DOD supported 89.8 percent of all federally funded R&D performed by industrial firms, 69.4 percent of all federally funded R&D performed by intramural performers, and 90.4 percent of all federally funded R&D performed by FFRDCs administerd by nonprofit institution. In comparison, DOD's share of Federal support to university performers was only 18.8 percent.[22]

As shown in table IV H, industry is the largest performer of total DOD RDT&E (estimated at 71.7 percent in fiscal year 1986), followed by intramural performers, universities and Federal Contract Research Centers (which are FFRDCs). Industry is also the largest performer of DOD science and technology work (6.1, 6.2 and 6.3A). See table IV I. However, universities perform the bulk of basic research (category 6.1) at 50 percent, followed by intramural performers, at 30 percent, and industry at 20 percent.[23] See table IV I. Most individual 6.1 research projects are funded at the level of less than $100,000 each, with fewer than 15 percent exceeding $15,000.[24]

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[20] Davis, Bennie, op. cit., p. 58.

[21] Memorandum from Caspar Weinberger. Subject Funding for the Technology Base (Budget Categories 6.1 and 6.2), Aug. 4, 1984.

[22] Based on data in table C-9. U.S. National Science Foundation. Federal Funds for Research and Development: Fiscal Years 1985, 1986, and 1987. v. xxxv. Detailed Statistical Tables.

[23] Colonel Donald I. Carter. The Department of Defense Statement on Science in the Mission Agencies and Federal Laboratories. Before the Task Force on Science Policy of the Committee on Science and Technology, 99th Cong., 1st Sess., Oct. 2, 1985.

[24] DOD. Basic Research Program, op. cit., table A-5.

Table IV H*

## RDT&E BY PERFORMER
### TOA ($ MILLIONS)
### FY 1988 / 1989 BUDGET ESTIMATE

| | FY 1986 | % | FY 1987 | % | FY 1988 | % | FY 1989 | % |
|---|---|---|---|---|---|---|---|---|
| Industry | 24186.6 | 71.8 | 25443.9 | 70.2 | 31556.4 | 72.2 | 31418.1 | 71.0 |
| Govt In-House | 8031.7 | 23.8 | 9058.3 | 25.0 | 10114.9 | 23.1 | 10586.4 | 24.0 |
| Federal Contract Research Ctrs (FCRCs) | 668.1 | 2.0 | 875.2 | 2.4 | 1053.8 | 2.4 | 1128.9 | 2.6 |
| Univerities | 789.7 | 2.4 | 884.6 | 2.4 | 994.8 | 2.3 | 1069.2 | 2.4 |
| TOTAL RDT&E | 33676.1 | 100.0 | 36[illegible]52.0 | 100.0 | 43718.9 | 100.0 | 44202.6 | 100.0 |

FY 1988

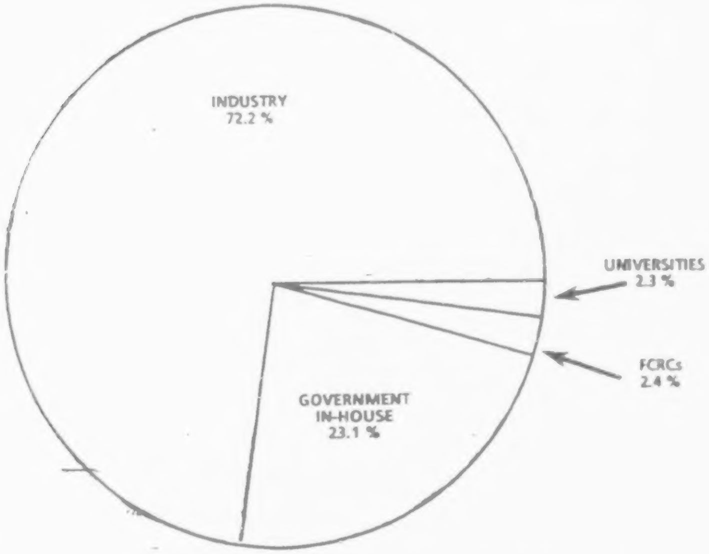

CHART 9

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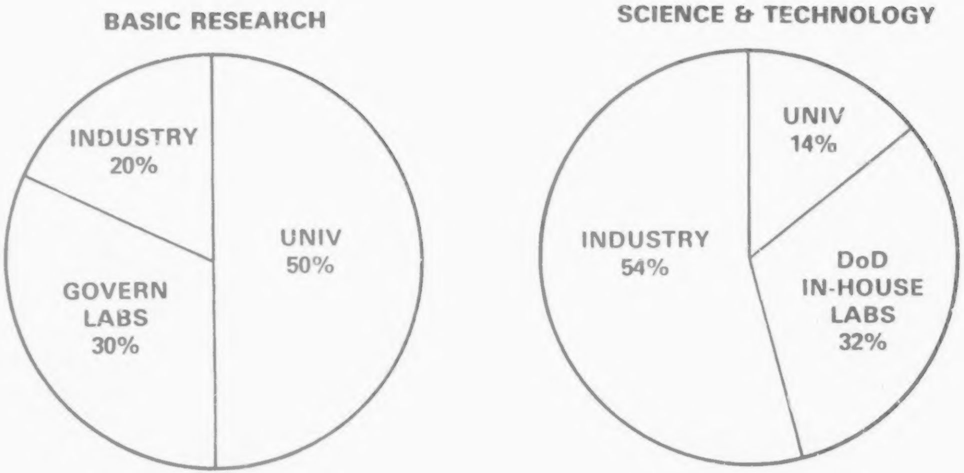
* Source: Statement by Richard P. Godwin. Under Secretary of Defense for Acquisition before the Research and Development Subcommittee , House Armed Services Comm. , March 4, 1987.

Table IV I

Performers of DOD Science and Technology*



BASIC RESEARCH

SCIENCE & TECHNOLOGY

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* The Department of Defense Statement on Science in the Mission Agencies and Federal Laboratories. By Donald I. Carter, Colonel, USAF, Acting Deputy Under Secretary of Defense for Research and Advanced Technology, Before the Task Force on Science Policy, Oct. 2, 1985.

The Navy tends to allocate most of DOD's basic research funds. Thus in fiscal year 1986, the distribution of basic research funds by DOD agency wide: Navy, 38.7 percent; followed by the Air Force, 28.6 percent; the Army, 25 percent, and the defense agencies, the Defense Advanced Research Projects Agency (DARPA) and the Uniformed Services University of Health Sciences (USUHS) (7.7 percent). See table IV J.

Table IV J

## RESEARCH (6.1) PROGRAM FUNDING[*]
## (DOLLARS IN MILLIONS)[1]

| | FY 82 | FY 83 | FY 84 | FY 85 | FY 86 PRES. BUDGET |
|---|---|---|---|---|---|
| ARMY | 178 | 202 | 218 | 234 | 268 |
| NAVY | 276 | 306 | 320 | 341 | 372 |
| AIR FORCE | 148 | 168 | 192 | 205 | 230 |
| DARPA | 92 | 101 | 108 | 81 | 99 |
| USUHS[1] | 2 | 2 | 2 | 2 | 2 |
| | 696 | 779[2] | 840[2] | 863[2] | 971[2,3] |

[1] UNIFORM SERVICES UNIVERSITY OF HEALTH SCIENCES

[2] INCLUDES $30M EACH YEAR FOR UPGRADE OF UNIVERSITY RESEARCH EQUIPMENT

[3] FY 86 INCLUDES $25M FOR UNIVERSITY RESEARCH INITIATIVE

[*] Source: Dr. Leo Young, Dept. of Defense, 1985.

The research offices of the three services, the Army Research Office (ARO), the Air Force Office of Scientific Research (AFOSR), the Office of Naval Research (ONR), and the Defense Advanced Research Projects Agency (DARPA) support most of DOD's basic research in universities. Significant research efforts in industry are supported by the military laboratories.[25] According to DOD, "the university program, as expected, tends to pursue research which offers long-term payoff, while that funded in industry is often nearer term and related more closely to the interests and needs of the sponsoring military laboratory." [26]

Military laboratories and industry have always performed more applied research, that is research in the 6.2 category than have universities.[27] This ratio of performers has not changed significantly in recent years.

A major issue of debate within the military establishment is the appropriate proportion of research that should be done in-house vs. extramurally in industry or universities. "The simple criterion of where can the work be done best is complicated by pressures to maintain certain in-house capabilities. Pressures also exist to maintain viable capabilities in industry as well." It has also been reported that "in-house laboratories, on occasion develop vested interests in certain kinds of work which they guard very jealously. . . .[28]

A significant amount of research work for the Strategic Defense Initiative Program, called Innovative Science and Technology (IST), although in budget category 6.3, is indistinguishable from 6.1 basic research. Universities are receiving increasingly greater amounts of funding from the SDI program. See table IV K.

TABLE IV K.*—SDI FUNDING TO UNIVERSITIES

[In millions]

| | Total SDI funds to universities | SDI funds to universities from the IST Office (research only) |
|---|---|---|
| Fiscal year | | |
| 1985 | $76.9 | $13.5 |
| 1986 | 152.0 | 50.0 |
| 1987 | 264.0 | 80.0 |

*Source: Interview with staff member of SDIO office.

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[25] U.S. Department of Defense. Basic Research Program, Sept. 1985, p. 5.

[26] Ibid., p. 5.

[27] Martin, Edith. The DOD Science and Technology Program: Some Management Perspectives. Army Research, Development & Acquisition Magazine, Sept.-Oct. 1983: 1.

[28] Landis, Lincoln, and Kendall W. Simmons. Science, Technology, Research, and Development. Washington, D.C., Industrial College of the Armed Forces, 1974. p. 81-82.

## TABLE IV L1.—DEPARTMENT OF DEFENSE OBLIGATIONS FOR RESEARCH AND BASIC RESEARCH, BY FIELD, FISCAL YEARS 1985, 1986 AND 1987 ESTIMATED

[In thousands of dollars]

| | Fiscal year 1985— | | Fiscal year 1986 estimated— | | Fiscal year 1987 estimated— | |
|---|---|---|---|---|---|---|
| | Total | Basic | Total | Basic | Total | Basic |
| Life Sciences | 271,951 | 103,791 | 265,843 | 106,749 | 300,201 | 104,387 |
| Psychology | 118,386 | 32,223 | 122,685 | 37,758 | 122,844 | 35,509 |
| Physical Sciences | 597,479 | 85,510 | 627,736 | 212,675 | 647,978 | 213,211 |
| Environmental Sciences | 273,853 | 119,746 | 303,362 | 1,42,228 | 330,123 | 151,839 |
| Mathematics and Computer Sciences | 300,376 | 100,252 | 391,591 | 130,767 | 457,288 | 110,095 |
| Engineering | 1,502,009 | 305,193 | 1,523,944 | 348,347 | 1,629,941 | 356,901 |
| Social Sciences | 4,711 | | 4,071 | | 4,238 | |
| Other Sciences NEC | 99,518 | 14,692 | 119,870 | 15,799 | 147,369 | 23,939 |

Note.—National Science Foundation data.

TABLE IV L2

## DEPARTMENT OF DEFENSE FUNDING FOR BASIC RESEARCH BY DISCIPLINE, FY 83, FY 84, FY 85 AND FY 86*
## (BUDGET AUTHORITY IN MILLIONS)

| | FY 83 | FY 84 | FY 85 | FY 86 |
|---|---|---|---|---|
| PHYSICS, RADIATION SCIENCES ASTRONOMY AND ASTROPHYSICS | 79.5 | 88.1 | 88.1 | 104.4 |
| MECHANICS, AERONAUTICS AND ENERGY CONVERSION | 79.5 | 84.8 | 91.5 | 96.0 |
| MATERIALS | 59.8 | 67.6 | 71.3 | 77.1 |
| ELECTRONICS | 65.8 | 73.9 | 78.9 | 84.7 |
| OCEANOGRAPHY | 51.2 | 53.6 | 54.4 | 59.9 |
| BIOLOGY AND MEDICAL SCIENCES | 64.8 | 75.9 | 82.8 | 93.3 |
| CHEMISTRY | 59.3 | 61.7 | 67.0 | 74.7 |
| MATHEMATICS AND COMPUTER SCIENCES | 56.9 | 60.0 | 67.3 | 69.2 |
| TERRESTRIAL SCIENCES | 24.8 | 27.3 | 26.1 | 30.8 |
| ATMOSPHERIC SCIENCES | 21.9 | 26.4 | 29.6 | 33.9 |
| BEHAVIORAL SCIENCES | 21.6 | 21.4 | 27.3 | 28.3 |
| SPECIAL STUDIES | 3.3 | — | — | — |
| UNIVERSITY INSTRUMENTATION | 30.0 | 30.0 | 30.0 | 30.0 |
| ILIR | 57.9 | 58.4 | 64.3 | 69.0 |
| SUBTOTAL | 676.4 | 729.1 | 778.6 | 851.1 |
| DEFENSE ADVANCED RESEARCH PROJECTS AGENCY | 101.0 | 111.9 | 80.7 | 92.5 |
| UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES | 2.0 | 1.4 | 2.0 | 2.0 |
| UNIVERSITY RESEARCH INITIATIVE | — | — | — | 25.0 |
| TOTAL | 779.4 | 842.4 | 861.3 | 970.6 |

* Dr. Leo Young, Dept. of Defense, 1985.

### 6. PRIORITIES FOR LONG VERSUS SHORT-TERM RESEARCH

As noted above, as a proportion of all RDT&E, military support for 6.1 and 6.2 technology base work research reached an all time high in the post-Sputnik years, prior to the Vietnam War, see table IV E. For the last 20 years, that is 1966 to 1986, the amount of funding for technology base work, when expressed in terms of constant dollars, has been lower than the amount available in 1963, the year before which military research funding started decreasing. Funding levels for technology base work in the fiscal years 1975 and 1985 were only 50 percent of the 1965 level in terms of real buying power.[29] Other decisions also accompanied the choice to decrease military research funding as a percentage of DOD RDT&E. These included: (1) a cutback in funding for long-term basic research and an emphasis on research to support near-term projects, (2) a cut in funding for research performed in universities, coupled with a concomitant increase in intramural laboratory research, (3) increases in laboratory support for applied research, and (4) transfer of some defense research to civilian agencies (such as materials research laboratories to the National Science Foundation.

Several factors caused these trends. The pressures of the Vietnam War tended to shift the focus of RDT&E to short-range work and efforts to improve battlefield weapons. At the same time the passage of the Mansfield amendment, which required that DOD-supported research be relevant to the DOD mission, trimmed and refocused a considerable amount of the basic research support program. (See chapter III of this study.)

### 7. MILITARY RESEARCH FUNDING BY DISCIPLINE

DOD supports significant amounts of federally funded research[30] in critical areas of science. In the fiscal year 1987, estimated DOD obligated about 21 percent of all Federal funds for research (an estimated $3.6 billion out of Federal obligations for research estimated to total $16.8 billion). DOD funded 38 percent of Federal support for research in psychology, 59 percent of all Federal research for mathematics and computer sciences, and 41 percent of all Federal support for engineering. (NSF data.) Funding levels for basic research, by discipline, are displayed in figures IV L1. Figure IV L2 displays information using the technical fields of the DOD nomenclature. Figure IV L arrays the data according to the fields of science categories used by the National Science Foundation. The largest amounts of 6.1 DOD or basic research support goes to the physical sciences (physics, radiation sciences, astronomy, and astrophysics; electronics) and engineering (mechanical, aeronautics, and energy conversion) materials sciences, mathematics and computer sciences, chemistry, environmental sciences and psychology.[31]

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[29] Suttle, Jimmie R., op. cit., p. 4.

[30] This refers exclusively to funding for research, as distinguished from funding for research and development.

[31] See also U.S. National Science Foundation. The DOD Share in Federal R&D Funding. In Federal Funds for Research and Development. Fiscal Years 1980, 1981, and 1982. Washington, U.S. Govt. Print. Off., 1982. p. 16. NSF 82-321.

## B. ORGANIZATION FOR RESEARCH MANAGEMENT

### 1. FUNCTIONS OF THE UNDER SECRETARY FOR DEFENSE RESEARCH AND ENGINEERING AND OF THE OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

The Office of the Director of Defense Research and Engineering was created pursuant to P.L. 85-599, the Department of Defense Reorganization Act of 1958. The status of the office was raised and its functions were expanded in 1977, following implementation by Secretary Brown of management reforms suggested by a Blue Ribbon Defense Panel under the direction of Secretary Packard. The office of the Director of Defense Research and Engineering (DDR&E) became the Under Secretary for Research and Engineering, and was given authority to manage the Department's weapons system acquisition process.[32] Until 1986, the Under Secretary for Research and Engineering had responsibility for research and development and chaired the Defense Systems Acquisition Review Council, or DSARC, which made decisions about which major weapons systems to purchase.[33] In 1985 the functions of the office of the Under Secretary were trimmed when Secretary of Defense Weinberger removed from the office "primary responsibility for overall production policy and some key production decisions." "The effect," according to *Science* magazine, "is to drive a wedge of sorts between those responsible for research and development and those responsible for production, with the result that fewer faulty weapons may get from the laboratory to the factory." [34] Prior to the reorganization, the President's Private Sector Survey on Cost Control (the Grace Commission created by the White House to examine waste and inefficiency in Government) had criticized the combination of functions. It recommended that the functions of weapons research and acquisition be separated to avoid conflict of interest. Subsequent to management reforms recommendations made in 1986 by the Packard Commission, the office of the Under Secretary for Research and Engineering was abolished and R&D management functions are now handled by the Director for Defense Research and Engineering, who reports to a new Under Secretary for Acquisition.[35] The details of the reorganization are pending.

Prior to the reorganization in 1986, the R&D activities of each branch of service and of defense agencies were coordinated by the Office of the Deputy Under Secretary for Research and Advanced Technology (ODUS R&AT). The office also served as a principal scientific advisor to the Under Secretary of Defense for Research and Engineering and was a major point of access for the scientific community. The Office was composed for five directors and their staffs. See figures IV M and IV N.

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[32] Deagle, Edwin A., Jr. Organization and Process in Military R&D. In Long and Reppy, op. cit., 1980. p. 172.

[33] The DOD Inspector General has criticized DSARC for approving some systems which are too costly and unreliable. See: R. Jeffrey Smith. Pentagon Decision-Making Comes Under Fire. Science, v. 227, Jan. 4, 1985: 32-33.

[34] Smith, R. Jeffrey. DOD Reorganizes Management. Science, Feb. 8, 1985: 613.

[35] P.L. 99-348, Military Retirement Reform Act of 1986 and P.L. 99-443, Goldwater-Nichols DOD Reorganization Act of 1986.

One director, the Director for Research and Laboratory Management (RLM), had responsibilities which included the 6.1 research program, university relations, independent research and development (IR&D), small business innovation research (SBIR), laboraroty management, the Defense Technical Information Center (DTIC), and export control issues. Two directorates, VHSIC, for very high speed integrated circuits and related technologies, and Computer Software and Systems, "took a very active role in the planning and execution of programs. . . ." [36] The other three directorates were engaged in more "traditional policy-guidance-oversight. . . ." [37] The Environmental and Life Sciences Directorates was concerned with technology applications in operational systems in areas arising from the supporting disciplines of: "training and personnel technology; medicine and life sciences; chemical warfare and chemical/biological defense; and environmental quality.[38] The Military Systems Technology Directors dealt with ". . . firepower and mobility' . . ., with responsibilities in the five related areas: electronic systems; combat vehicles; propulsion and fuels; conventional weapons; and materials and structures."

The ODUS (R&AT) was responsible for implementing DOD research policy, for oversight of the science and technology (S and T programs) funded by the military services and coordinated research programs across service lines. Interaction occurred as follows:

> The first way is through the mission area planning process, to determine the technology prospects and needs for future weapon systems. The second way is by providing assessments of technology readiness and payoffs for nearer term system developments. The third way is through efforts devoted to international technology exchange, cooperation, and export control; in this area, ODUSD (R&AT) also interacts with the Office of the Under Secretary for Policy.[39]

The Director (RLM) also chaired the tri-service Defense Committee on Research (DCOR). It is composed of members from the three services and the Defense Advanced Research Projects Agency (DARPA). The Committee's functions were as follows:

> [It] served as a coordinating and policy-making group in the Office of the Under Secretary of Defense for Research and Engineering. The group is concerned with interservice cooperation, the solution of managerial problems, and the consideration of urgent research needs.[40]

The Under Secretary of Defense for Research and Engineering reviewed the service research budgets annually (normally the office did not deal with funding for the other defense research agencies, which account for about 25 percent of the S and T program) [41] and held coordination meetings regularly with the Director of the National Science Foundation. Coordination was maintained also on activities of mutual interest such as research instrumentation and facilities with the National Institutes of Health, NASA, DOE, and other Federal agencies, as well as with the scientific community for example, through the National Academy of Sciences.

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[36] Martin, Sept.-Oct., 1983, op cit., p. 4.
[37] Ibid.
[38] Martin, Sept.-Oct., 1983, op cit., p. 5.
[39] Martin, Sept.-Oct. 1983, op. cit. p. 3.
[40] U.S. Department of Defense. Basic Research Program, Sept. 1985. p. 4.
[41] Martin, Sept.-Oct. 1983, op. cit. p. 3.

### 2. THE ARMY [42]

About 70 percent of the Army's research program is supervised by the Army Material Command (AMC), formerly called the Army Material Development and Readiness Command (DARCOM), which reports to the Director of Army Research and Technology. Within the AMC, the Army Research Office handles university research. In-house research is conducted in the Army's 35 laboratories, which are associated with the AMC. The rest of the basic research program is conducted by: the Surgeon General's Office and the Medical R and D command (24 percent), the Corps of Engineers (4 percent), and the Army Research Institute for the Behavioral and Social Sciences (2 percent). (See table IV O)

The Army's laboratory research, is funded by a "Single Project Funded (SPF) line item which relates more closely to the overall mission of the laboratory than to some specific scientific discipline." Technical programs are "formally reviewed annually by each Command Headquarters and by the Directorate of Army Research and Technology." The director of Army Research and Technology also identifies "technology thrusts", research focused on a particular problem or areas that is performed by "several laboratories in-house and on contract within their respective SPF's."

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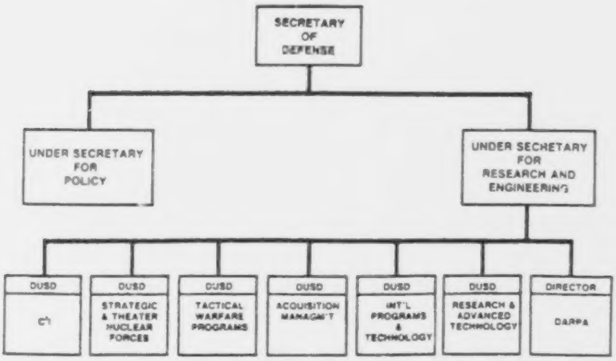
[42] Most of the following information is adapted from: U.S. Department of Defense. Basic Research Program, Sept. 1985. p. 67-70.

Figure IV M 1

Partial Organization of the Office of the Secretary of Defense*


SECRETARY OF DEFENSE
UNDER SECRETARY FOR POLICY
UNDER SECRETARY FOR RESEARCH AND ENGINEERING
DUSD
$C^3$
DUSD
STRATEGIC & THEATER NUCLEAR FORCES
DUSD
TACTICAL WARFARE PROGRAMS
DUSD
ACQUISITION MANAGM'T
DUSD
INT'L PROGRAMS & TECHNOLOGY
DUSD
RESEARCH & ADVANCED TECHNOLOGY
DIRECTOR
DARPA

---

* Martin, Edith. The DOD Science and Technology Program: Some Management Perspectives. Army Research, Development & Acquisition Magazine, v. 24, Sept.- Oct. 1983: 3.

Chart IV M 2 *

# DEFENSE ACQUISITION ORGANIZATION

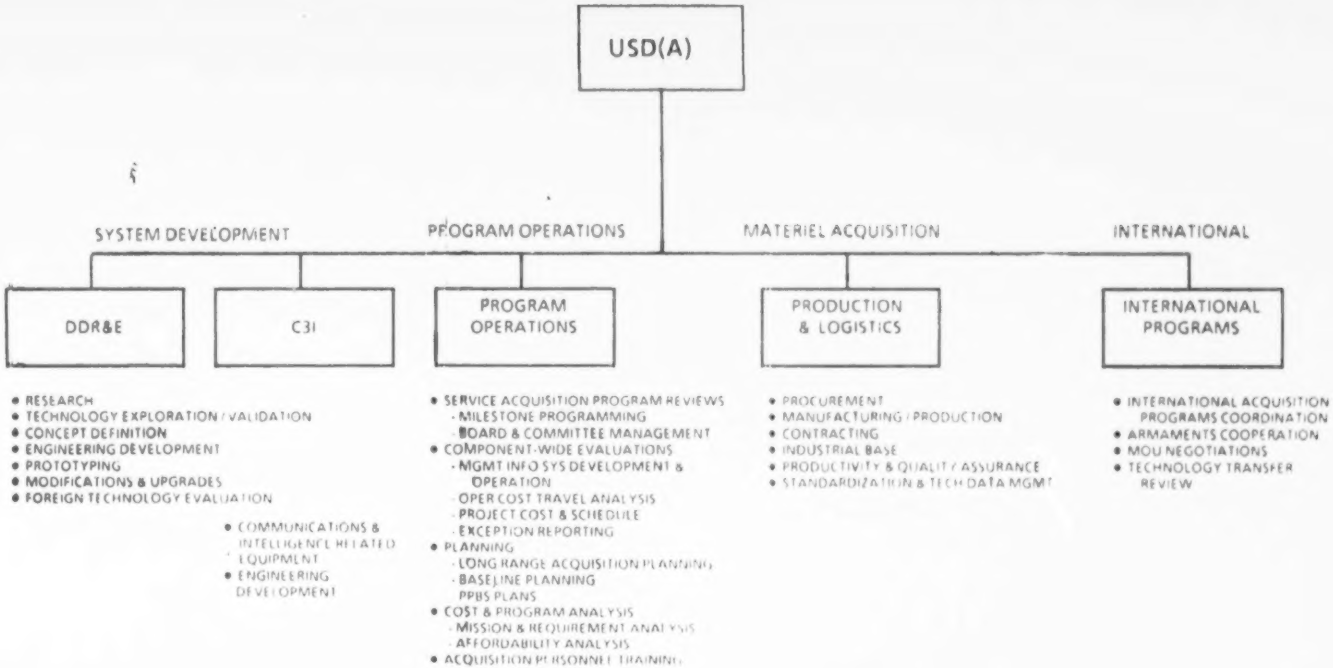
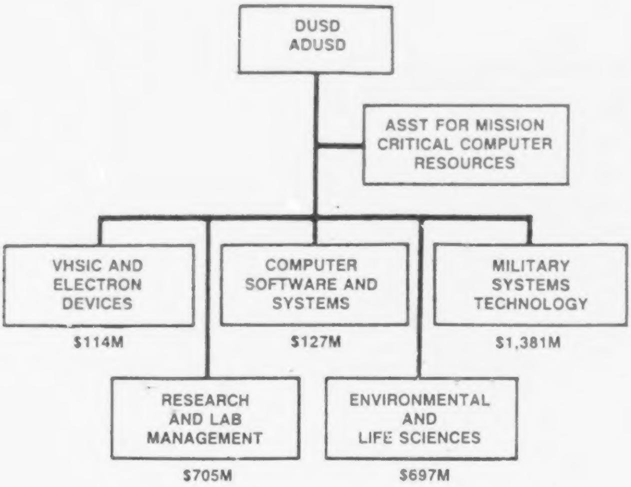

USD(A)
SYSTEM DEVELOPMENT
PROGRAM OPERATIONS
MATERIEL ACQUISITION
INTERNATIONAL
DDR&E
C3I
PROGRAM OPERATIONS
PRODUCTION & LOGISTICS
INTERNATIONAL PROGRAMS
• RESEARCH
• TECHNOLOGY EXPLORATION / VALIDATION
• CONCEPT DEFINITION
• ENGINEERING DEVELOPMENT
• PROTOTYPING
• MODIFICATIONS & UPGRADES
• FOREIGN TECHNOLOGY EVALUATION
• COMMUNICATIONS & INTELLIGENCE RELATED EQUIPMENT
• ENGINEERING DEVELOPMENT
• SERVICE ACQUISITION PROGRAM REVIEWS
· MILESTONE PROGRAMMING
· BOARD & COMMITTEE MANAGEMENT
• COMPONENT-WIDE EVALUATIONS
· MGMT INFO SYS DEVELOPMENT & OPERATION
· OPER COST TRAVEL ANALYSIS
· PROJECT COST & SCHEDULE
· EXCEPTION REPORTING
• PLANNING
· LONG RANGE ACQUISITION PLANNING
· BASELINE PLANNING
PPBS PLANS
• COST & PROGRAM ANALYSIS
· MISSION & REQUIREMENT ANALYSIS
· AFFORDABILITY ANALYSIS
• ACQUISITION PERSONNEL TRAINING
• PROCUREMENT
• MANUFACTURING / PRODUCTION
• CONTRACTING
• INDUSTRIAL BASE
• PRODUCTIVITY & QUALITY ASSURANCE
• STANDARDIZATION & TECH DATA MGMT
• INTERNATIONAL ACQUISITION PROGRAMS COORDINATION
• ARMAMENTS COOPERATION
• MOU NEGOTIATIONS
• TECHNOLOGY TRANSFER REVIEW

CHART I

* Source: Statement by Richard P. Godwin, Under Secretary of Defense for Acquisition before the Research and Development Subcommittee, House Armed Services Comm., 100th Cong., 1st session, March 4, 1987.

Table IV N

Organization of the Office of the Deputy Under Secretary
Of Defense for Research and Advanced Technology *
(Date: 1983)


DUSD
ADUSD
ASST FOR MISSION CRITICAL COMPUTER RESOURCES
VHSIC AND ELECTRON DEVICES
$114M
COMPUTER SOFTWARE AND SYSTEMS
$127M
MILITARY SYSTEMS TECHNOLOGY
$1,381M
RESEARCH AND LAB MANAGEMENT
$705M
ENVIRONMENTAL AND LIFE SCIENCES
$697M

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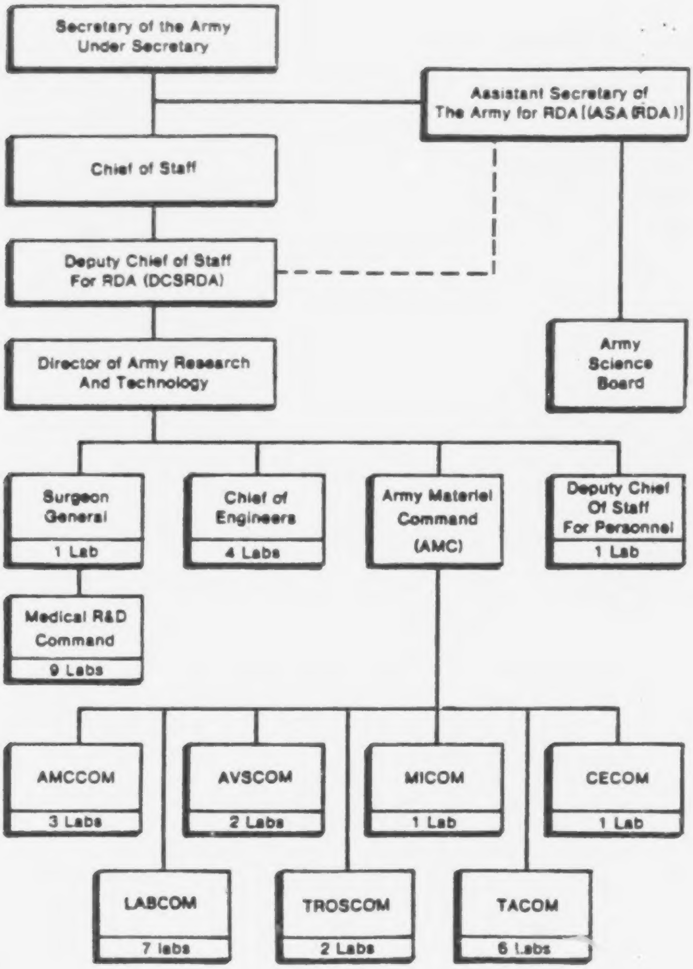
* Martin, Edith. The DOD Science and Technology Program: Some Management Perspectives. Army Research, Development & Acquisition Magazine, v. 24, Sept. - Oct. 1983: 4.

Figure IV 0

Army Research Management Structure*


Secretary of the Army
Under Secretary
Assistant Secretary of
The Army for RDA [(ASA (RDA)]
Chief of Staff
Deputy Chief of Staff
For RDA (DCSRDA)
Army
Science
Board
Director of Army Research
And Technology
Surgeon
General
1 Lab
Chief of
Engineers
4 Labs
Army Materiel
Command
(AMC)
Deputy Chief
Of Staff
For Personnel
1 Lab
Medical R&D
Command
9 Labs
AMCCOM
3 Labs
AVSCOM
2 Labs
MICOM
1 Lab
CECOM
1 Lab
LABCOM
7 labs
TROSCOM
2 Labs
TACOM
6 Labs

---

* Department of Defense. Basic Research Program, Sept. 1985, p. 65.

### 3. THE NAVY [43]

The Office of Naval Research (ONR), under the direction of the Chief of Naval Research, reports directly to the Assistant Secretary of the Navy for Research, Engineering and Systems. ONR was created in 1946 pursuant to P.L. 588, 79th Congress. (See chapter III in this study.) The Office is responsible for fulfilling the research requirements of the Navy and Marine Corps. ONR funds all but the medical research in the Navy. ONR funds both basic research and applied research and exploratory development. In particular, ONR administers the Navy's contract research program. The Navy's in-house research is conducted at the Naval Research Laboratory (NRL), the Naval Research and Development Activity NORDA), the Naval Biosciences Laboratory (NBL), and in the laboratories of the Naval Material Command R and D Centers and the Naval Medical R and D Command.

By far the largest performer of in-house research in the Navy is the Naval Research Laboratory, with about 24 percent of its budget going for military research and the rest for other RDT&E categories. A small amount of research is managed for ONR by the Naval Systems Command, which manages mostly development contracts. ONR, under the direction of the Chief of Naval Research (CNR) reports to the Assistant Secretary of the Navy for Research, Engineering and Systems. Liaison is maintained by the DCRN with the Office of the Chief of Naval Operations. In a 1985 reorganization, the CNR was given responsibility for Navy laboratories. See figure IV P.

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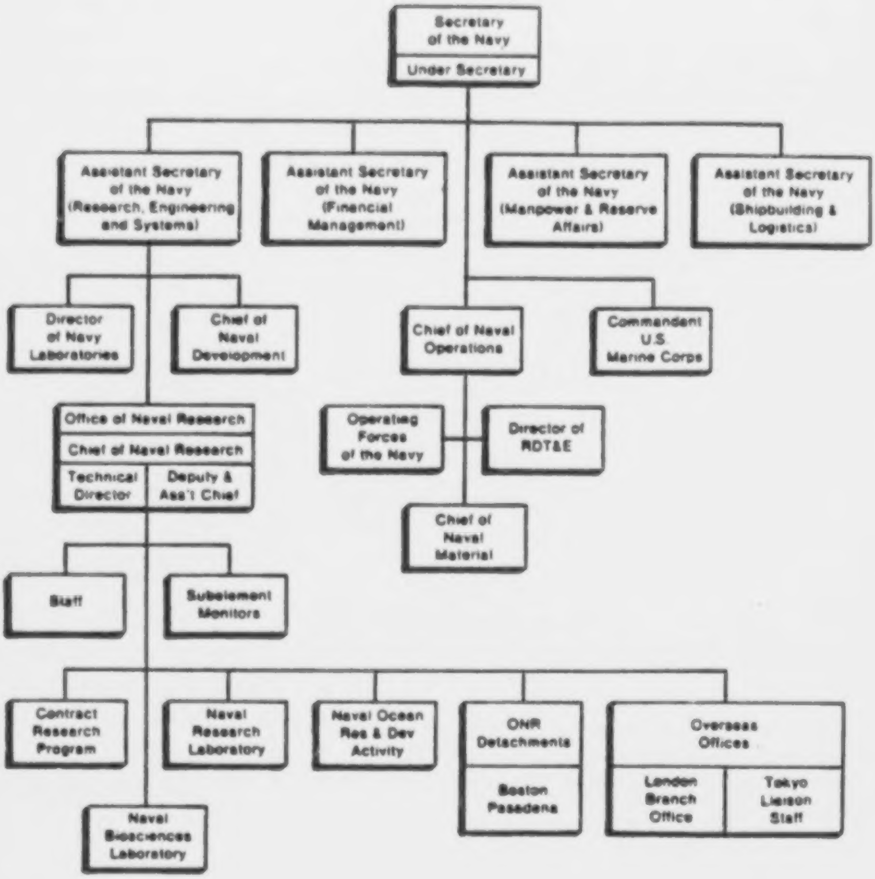
[43] Adapted from Department of Defense. Basic Research Program. Sept. 1985. p. 71-74.

Figure IV P

Navy Research Management Structure*


Secretary of the Navy
Under Secretary
Assistant Secretary of the Navy (Research, Engineering and Systems)
Assistant Secretary of the Navy (Financial Management)
Assistant Secretary of the Navy (Manpower & Reserve Affairs)
Assistant Secretary of the Navy (Shipbuilding & Logistics)
Director of Navy Laboratories
Chief of Naval Development
Chief of Naval Operations
Commandant U.S. Marine Corps
Office of Naval Research
Chief of Naval Research
Technical Director
Deputy & Ass't Chief
Operating Forces of the Navy
Director of RDT&E
Chief of Naval Material
Staff
Subelement Monitors
Contract Research Program
Naval Research Laboratory
Naval Ocean Res & Dev Activity
ONR Detachments
Boston Pasadena
Overseas Offices
London Branch Office
Tokyo Liaison Staff
Naval Biosciences Laboratory

* Department of Defense. Basic Research Program, Sept.1985, figure 23.

The Navy has the largest research support program of any of the services, although the Air Force spends more on total RDT&E. Unique naval research needs focus on acoustics and electronics.

### 4. THE AIR FORCE [44]

All Air Force defense research science (in-house and extramural) is managed by the Air Force Office of Scientific Research (AFOSR), which is organized by scientific discipline. According to DOD,

> The Air Force basic research program . . . is directed toward advancing the state-of-the-art in areas related to the technical problems encountered in developing and maintain a qualitative superior Air Force; in improving the performance, maintainability, and supportability, and lowering the cost of Air Force weapon systems; and in creating and preventing technological surprise.[45]

The subordinate units of the AFOSR include the European Office of Aerospace Research and Development in London and the AFOSR Far East, which gather information about foreign research and promote communications between Air Force scientists and their counterparts, and the Frank J. Seiler Research Laboratory in Colorado Springs, which performs intramural research. About 65 percent of the AFOSR's basic research program goes to extramural grants and contracts to academic and industrial performers. AFOSR also funds research at the following laboratories: Air Force Armament Laboratory, Air Force Geophysics Laboratory, Air Force Rocket Propulsion Laboratory, and the Air Force Wright Aeronautical Laboratories, the Aerospace Medical Division, the Air Force Weapons Laboratory, and the Rome Air Development Center. See figure IV Q.

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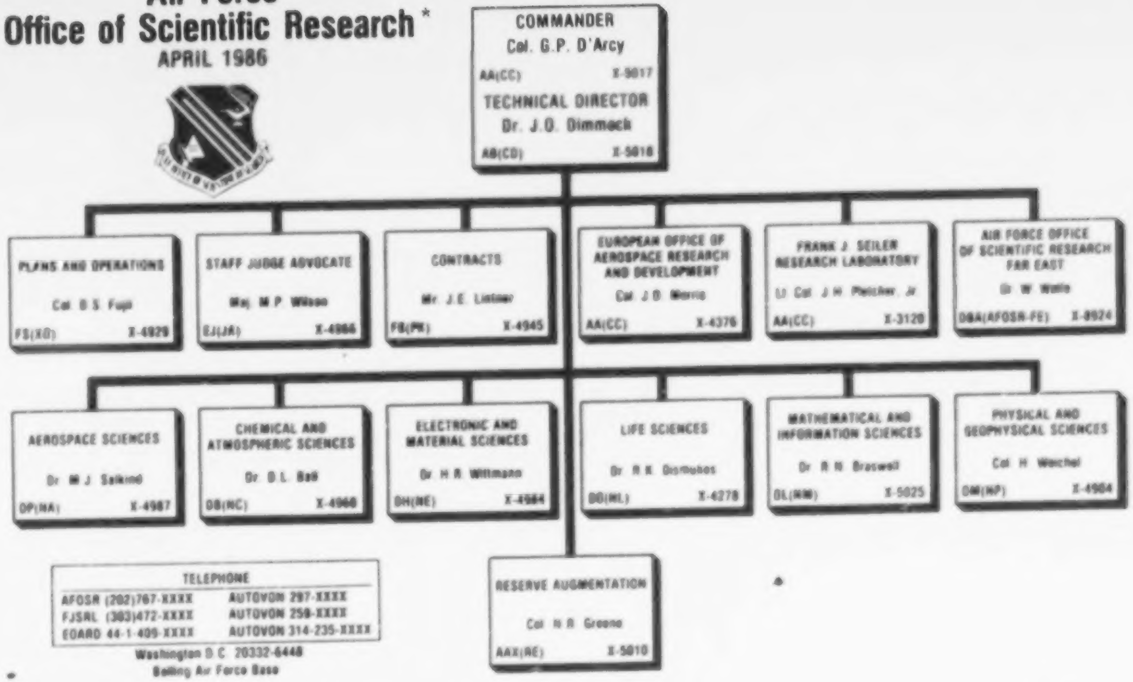
[44] Adapted from Department of Defense. Basic Research Program. Sept. 1985. p. 785-76.

[45] U.S. Department of Defense. Basic Research Program, Sept. 1985. p. 75.

Figure IV Q

# Air Force Office of Scientific Research *

APRIL 1986


COMMANDER
Col. G.P. D'Arcy
AA(CC) X-5017
TECHNICAL DIRECTOR
Dr. J.O. Dimmock
AB(CD) X-5018
PLANS AND OPERATIONS
Col D S Fuji
FS(XO) X-4929
STAFF JUDGE ADVOCATE
Maj M P Wilson
EJ(JA) X-4966
CONTRACTS
Mr J.E. Listner
FB(PK) X-4945
EUROPEAN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT
Col J D Morris
AA(CC) X-4376
FRANK J. SEILER RESEARCH LABORATORY
Lt Col J H Fletcher, Jr
AA(CC) X-3120
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH FAR EAST
Dr W Wells
DBA(AFOSR-FE) X-8924
AEROSPACE SCIENCES
Dr M J Salkind
OP(NA) X-4987
CHEMICAL AND ATMOSPHERIC SCIENCES
Dr D L Ball
DB(NC) X-4960
ELECTRONIC AND MATERIAL SCIENCES
Dr H R Wittmann
DH(NE) X-4984
LIFE SCIENCES
Dr R K Dismukes
DD(NL) X-4278
MATHEMATICAL AND INFORMATION SCIENCES
Dr R N Braswell
DL(NM) X-5025
PHYSICAL AND GEOPHYSICAL SCIENCES
Col H Weichel
DM(NP) X-4904
RESERVE AUGMENTATION
Col N R Greene
AAX(RE) X-5010

TELEPHONE

| | |
|---|---|
| AFOSR (202)767-XXXX | AUTOVON 297-XXXX |
| FJSRL (303)472-XXXX | AUTOVON 259-XXXX |
| EOARD 44-1-409-XXXX | AUTOVON 314-235-XXXX |

Washington D C 20332-6448
Bolling Air Force Base

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* Department of Defense. Basic Research Program, Sept. 1985.

The Air Force laboratories that perform research for AFOSR also assist the AFOSR in monitoring research contracts and grants with industry and universities. In a typical year, half of the laboratory funds go to intramural research and half go to contracts.

### 5. THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)

The Defense Advanced Research Projects Agency (DARPA) was created as the Advanced Research Projects Agency, ARPA, pursuant to P.L. 85-325 in 1958, in response to pressure caused by the launching of the Soviet satellite Sputnik and ". . . partly in response to the urgent need for high-level attention to selected research projects stemming from promising advanced concepts and requiring long-range development."[46] In 1972, it added the word "Defense" to its title. The early history of DARPA was summarized in the study, *The Advanced Research Projects Agency, 1958-1974.*[47]

#### *a. DARPA's objectives*

DARPA is a separate defense research agency that provides a corporate or centralized research function and serves as a "door opener" to new technological ideas." [48] According to DOD,

> Its programs focus on proof-of-concept demonstrations of revolutionary approaches for improved strategic, conventional, rapid deployment, and sea-power forces, and on the scientific investigation into advanced basic technologies of the future. . . . Thus DARPA is able to explore the possible military benefits of new and unconventional concepts and technologies for all military services, without regard to the specific roles or missions which their applications might have.[49]

DARPA's appropriated budget was about $700 million in FY 1986; [50] it has a staff of about 125 to 150 employees.[51] Recently DARPA's budget was cut and some of its program was transferred to the Strategic Defense Initiative Office. Further, it absorbed a 9 percent reduction in FY 1986 to protect the SDI budget from incurring across-the-board reductions of the Gramm-Rudman-Hollings budget reduction measure. Its FY 1986 budget request was $87 million below the agency's appropriation for the fiscal year 1984 and is about the same as the 1982 budget in terms of constant dollars.

DARPA does not operate laboratories or do in-house research. Its small size is intended to foster the rapid circulation of new and creative ideas and help avert bureauractic inertia. It supports promising, but risky initiatives which might advance U.S. national security interests. DARPA staff may perceive an objective, such as in computerization and fund a series of coordinated research projects simultaneously in hopes of reaching the objective. This practice tends to generate good science. Its contrast with NSF has been described as follows:

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[46] U.S. Department of Defense. Basic Research Program, Sept. 1985. p. 77.

[47] The Advanced Research Projects Agency, 1958-1974. A study prepared by Richard J. Barber Associates, Inc., Dec. 1975, various pagings.

[48] U.S. Department of Defense, Basic Research Program, op. cit., p. 45.

[49] Ibid., p. 77.

[50] Defense Agencies RDT&E Programs. Defense Daily, Jan. 12, 1987: p. 51.

[51] Botkin, James and D. Dimancescu. The DARPA Exception. In Tirman, John, ed. The Militarization of High Technology. Cambridge, Ballinger Publ. Co., 1984. p. 122 and Boffey, Philip M. Small Agency Quietly Plays Powerful Role in Developing Exotic Research. New York Times, Apr. 23, 1985: p. C1, C5.

> In contrast to DARPA, the National Science Foundation (NSF) is one of the largest of the government's civilian research agencies. Its major focus is science departments of universities to which it provides about $1 billion per year in grants. It's principal strategy is to disperse its resources among individual researchers or small groups, and its awards are based on proposal reviews and approved by peers. This approach, because it is highly fragmented, lacks the solid, tightly concentrated focus of DARPA. Its strength on the other hand is in helping to sustain a broad base of scientific activity within the American research community.[52]

According to one view "DARPA generally funds an idea only long enough to determine its feasibility. If it seems clear that the idea will not pan out, the project is dropped."[53] James A. Tegnelia, Acting Director of DARPA, testified at hearings before the House Committee on Science and Technology Task Force on Science Policy on October 2, 1985 that:

> Research concepts or projects usually are explored for about three to six years to verify or disprove their viability. . . . Those that are judged successful are transferred out through: (a) joint service efforts; (b) pervasive incorporation in Service and/or private sector development efforts (this is particularly true of successful basic or applied research efforts); or (c) by self-imposed termination even if judged by DARPA to be successful.

In making its decisions regarding project transfer or termination, DARPA receives technical review and advice internally and from "external groups, such as the Defense Science Board, Jasons, USDRE's Advisory Group on Electron Devices, and DARPA's Materials Research Council." [54]

The military services are involved in planning DARPA's objectives.[55] Most of DARPA's research is contracted through the military services, and DARPA funds frequently augment each Service's Office of Scientific Research (OXR) funds or OXR contracts.

DARPA's basic technology projects focus on long-term research in six general areas. The present technical office organization: strategic technology, directed energy, tactical technology, information processing, defense science, and engineering applications." [56] See Table IV R. The Defense Science Office supports advanced R and D through three divisions: geophysical sciences, materials sciences, and electronic sciences. "The objectives of R&D efforts in this field are to support national security in the area of nuclear monitoring, to support the military services in developing advanced materials leading to new structures or electronic and electro-optic components and devices, and to advance system technologies for improved military operations." [57]

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[52] Botkin, James, Dan Dimancescu, and Ray Stata. The Innovators. Rediscovering America's Creative Energy. New York, Harper and Row, 1984, p. 256.

[53] Lerner, Eric J. Technology and the Military: DOD's DARPA at 25. IEEE Spectrum, Aug. 1983. 71.

[54] Statement of James A. Tegnelia, Before the House Committee on Science and Technology Task Force on Science Policy, Oct. 2, 1985. p. 2-3.

[55] Department of Defense. Basic Research Program, Sept. 1985. p. 77.

[56] Ibid., p. 77.

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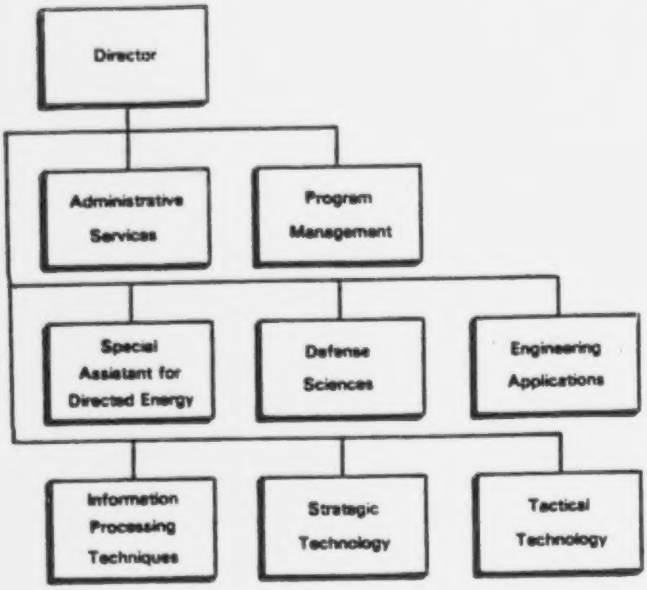
[57] Ibid., p. 79.

Figure IV R *

1985
DARPA Managment Structure


Director
Administrative Services
Program Management
Special Assistant for Directed Energy
Defense Sciences
Engineering Applications
Information Processing Techniques
Strategic Technology
Tactical Technology

---

* Department of Defense. Basic Research Program, Sept. 1985, p. 78.

DARPA has been credited with supporting the research that generated the cruise missile; the commercially useful Arpanet computer linking network, which was based on development of time-sharing technology funded by DARPA; [59] phased-array and over-the-horizon radar; "large acoustic arrays"; and rocket propulsion work which generated rockets used in the space program.[60] The agency also supported the development of the prototype of the "mouse" control devise used on many personal computers, and the miniaturization of much computer technology.[61] DARPA has also been credited with having supported the basic research which:

> . . . originated packet switching, now applied to the civilian telephone network . . . [and with] artificial intelligence, parallel computing, speech understanding, natural-languages programming . . . time-sharing and high-level computer languages.[62]

DARPA funding is provided in the three categories of 6.1, 6.2 and 6.3A. Basic research funding constitututes about 12 percent of the DARPA budget.[63] Most of DARPA's basic research is conducted by universities. Some academicians, reportedly, eagerly seek DARPA research support because of its innovative nature and because less paperwork is required, and the proposal preparation process is less tedious than in some other research agencies.[63a] According to James Botkin and Dan Dimanescu DARPA has concentrated its 10 percent of resources that go to universities in a few major research institutions, such as M.I.T., Carnegie-Mellon, Stanford and University of California, Berkeley. This approach, they say, generates ". . . a sufficient mass of resources to take on complex and challenging research projects" and has helped to train scientific personnel and leaders in certain fields.[64]

### *b. DARPA's funding mechanisms and products are praised*

DARPA's research funding mechanisms have been widely acclaimed on several grounds. DARPA solicits proposals from universities, and readily funds proposals without the bureaucratic red tape and competition that characterizes funding from civilian agencies. For instance:

> DARPA's philosophy is to select competent, proven staff professionals and then to delegate authority to make significant and far-reaching decisions.[65]
>
> Innovation is ultimately a risky business, and any effort to mitigate this risk through collective committee action characteristic of other research support agencies is said to compromise the cutting edge of technological advance.[66]

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[59] Lerner, Eric J. Technology and the Military: DOD's DARPA at 25. IEEE Spectrum, Aug. 1983: 71. See also: The DARPA Exception, In Tirman, op. cit., p. 223.

[60] Lerner, op. cit., p. 72

[61] Ibid.

[62] Lerner, op. cit., p. 72.

[63] Botkin, James, Dan Dimanescu, and Ray Stata, The Innovators. Rediscovering America's Creative Energy. New York, Harper and Row, 1984. p. 252. See also Statement of James Tegnelia before the House Committee on Science and Technology Task Force on Science Policy, Oct. 2, 1985. p. 6.

[63a] Botkin, op. cit., p. 252-266.

[64] Ibid., p. 224

[65] Botkin and Dimanescu, the DARPA Exception. In Tirman, The Militarization of High Technology, op. cit., p. 223.

[66] Ibid.

> . . . A great deal of DARPA's innovative strength is derived from the fact that it is not directly accountable to the armed services as end users, nor are they beholden to a rigid schedule that would compromise research goals. DARPA is also permitted to fail on some of its projects, which allows it to take the high risks others might steadfastly avoid.[67]

DARPA has also been widely praised for its leadership by noted scientists.[68] The model is so highly regarded that proposals have been made for the services to establish research operations like DARPA for themselves. In addition, recommendations have been made to create a civilian equivalent of DARPA which would have the authority to fund applied research in crucial areas.[69]

### *c. Criticism of DARPA*

DARPA's procedures and operations have however also been criticized. During a 1981 summer study, the Defense Science Board criticized the DARPA staff capability and lack of coordination with the services. It reported that:

> The growth in the DARPA technology base program has greatly exceeded the capability of the staff to properly execute the program; and there appears to be no comprehensive filtering of DARPA programs versus ongoing Service efforts and the DARPA results are not widely disseminated, therefore, not sufficiently critiqued.[70]

It argued for more service review of DARPA programs to ensure relevance:

> That USDRE should direct that Services review DARPA programs over $30 million (total program costs-not annual) from the point of view of potential future military applications, operational needs, and transition plans, and establish a mechanism to ensure coordination of system technology base programs with the rest of the DOD technology base activity to ensure that multiple system requirements are included in the development of the technology base investment strategy.[71]

There is also controversy about whether DARPA is funding too much applied research and prototype development too close to the stage of deployment of specific military technology, and insufficient amounts of longer range basic work. In the past DARPA developed a reputation of funding work at the cutting edge of both civilian and military science and applications, for instance computer science.[72] During hearings held by the House Task Force on Science Policy of the House Committee on Science and Technology, Norman R. Augustine, a member of the DSB and executive vice president of Martin Marietta corporation testified that:

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[67] Ibid., p. 224.

[68] "The list of past directors includes such scientists as J.C.R. Licklider, I.E. Sutherland, L.G. Roberts, and . . . R.E. Kahn. Each has earned international recognition for significant technical contributions, and all are held in highest respect by their peers in industry and universities." (Botkin and Dimanescu in The DARPA Exception, in Tirman, The Militarization of High Technology, op. cit., p. 223.

[69] Lerner, op. cit., p. 72.

[70] McIntyre, John J. Defense Science Board Reports on the Technology Base. Defense Science, May/June 1982: 42, 44-45, 63.

[71] Ibid.

> . . . In decades past the efforts of the [Defense] Advanced Research Projects Agency were focused upon advancing basic research and applied research. Over the years since its inception, however, the funds allowed to DARPA have been, to an increasing degree, used for prototype demonstrations—a very worthwhile undertaking in its own right but nevertheless still a major drain on the basic research resources originally intended at the time DARPA was established.[73]

However, it was reported that in September 1986 the Department of Defense "announced that DARPA's role in the weapon development process will be expanded to include prototyping and proof-of-concept demonstration. The new role embraces a recommendation of the Packard Commission to widen DARPA's role." [74]

Customarily it is acknowledged that the foundations of U.S. civilian and military computer science were built by DARPA. But today there is concern that too much of DARPA's computer research will go to specific military applications:

> For example, DARPA . . . will spend about $130 million of its $245 million information-processing research budget [for fiscal year 1986] . . . on battlefield computers that can "see" and "think" for use with specific weapons systems.[75]

Specifically, DARPA is reported to be developing applications of artificial intelligence research as follows: for the Navy, a battle management system, which would" . . . evaluate the progress of a battle situation, devise strategy, and then explain it to the admirals in plain English";[76] for the Air Force, DARPA is attempting to do work to develop a "pilot's associate" computer device, which would make decisions for a pilot in a battlefield situation; and for the Army, ". . . DARPA already has demonstrated a scaled-down version of an "autonomous land vehicles" that would be sent into uncertain terrain to reconnoiter, interpret and report what it "sees." [77] (See chapter VII for the view that artifical intelligence may be advanced best when challenged to address real problems, so that these "practical applications" may be part of a research strategy, not a move into technology development, per se.)

The following have been identified among the DARPA's current leading lines of effort:

> Now the agency is exploring a range of new technologies that could revolutionize both warfare and the civilian

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[72] Wynter, Leon E. Defense Agency's Research Role Stirs Debate, Pure Science is Seen Giving Way to Direct Military Uses. The Wall Street Journal, Oct. 24, 1985: 6.

[73] Testimony of Norman R. Augustine before the Task Force on Science Policy of the House Committee on Science and Technology, Oct. 23, 1985. p. 3-4.

[74] DARPA Receives Greater Role. Defense Week, Sept. 22, 1986: p. 3.

[75] Wynter, op. cit., p. 6.

[76] Wynter, op. cit., p. 6.

[77] Wynter, op. cit., p. 6.

> economy in the next century. Among the designs its hopes to push foward are . . . new materials that would allow aircraft engines to operate at far higher temperatures for far longer periods than current models, and new electronic components far faster than those that have already revolutionized the computer and electronics industries.[78]

Additional emphases include work on: gallium arsenide technology as a basic electronic material; mercury cadmium telluride; infrared focal plane arrays, for applications in infrared surveillance systems for strategic purposes; ultra-violet lasers; optical signal processing; directed energy (which accounts for about 25 percent of the overall DARPA budget); submarine laser communication; free electron laser; particle beam weapon technology; [79] and biochemistry ("chemical monitoring devices and visco-elastic biopolymer, which could be used in building fast, quiet marine vehicles. . . .") [80]

It has also been reported that at times the military services have objected to DARPA's ideas and have resisted development and deployment of new technologies. In many cases the problem may be simply the conservatism of the services or their commitment to solutions other than those DARPA has researched.[81]

### C. The Importance of the Soviet Threat in Program Formulation

DOD's science and technology programs are intended to support a multifaceted set of goals and objectives. The major reasons for pursuing 6.1 research, according to DOD, are to reduce the chance of long-term technological surprise and to enable scientific breakthroughs to be exploited quickly for defense purposes.[82] An additional goal is to "substitute technology for manpower" and to overcome the advantages of potentially better trained and more numerous "enemy" manpower.[83]

#### 1. GOALS OF DOD SCIENCE AND TECHNOLOGY MISSION DEFINED IN RESPONSE TO MILITARY THREATS

DOD holds a broad view of its science and technology mission in relation to the concept of "national security." Dr. Edith W. Martin outlined five major goals in 1983 when she was Deputy Under Secretary of Defense for Research and Advanced Technology.[84] These are to: (1) offset Soviet numerical superiority, (2) keep ahead of growing Soviet threat. (3) reduce complexity and costs, (4) improve productivity of industrial base, (5) enhance return on investment. The first two of these goals will be described next.

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[78] Boffey, Small Agency Quietly Plays Powerful Role in Developing Exotic Research, op. cit., p. C1.

[79] Cooper, Robert S. DARPA R&D Program. In Proceedings of The DOD FY84 Research and Development Program, Symposium. Apr. 19-21, 1983, Arlington, Virginia. Washington, D.C., Electronic Industries Association, 1983. p. 41-48.

[80] Leapfrog. Research Agency Describes Some of its High-Risk, High-Payoff Ventures. Defense Week, Apr. 8, 1985: p. 15.

[81] Lerner, op. cit., p. 71.

[82] U.S Dept. of Defense. Basic Research Program, [1984]. p. 4.

[83] Reppy and Long, op. cit., p. 36.

[84] Martin, Edith W. The DOD Science and Technology Program: Some Management Perspectives. Army Research, Development, & Acquisition Magazine, v 24, Sept-Oct. 1983. p. 1-5. See also Martin, Edith W. Managing Science and Technology For the Future. Defense Sciences DS2003+, Aug/Sept. 1985: p. 467-47.

Offset Soviet Numerical Superiority. The objective is "not to attempt to match our potential adversaries . . . on a person-to-person, weapon-for-weapon basis . . . [but] to rely on our superior technology . . . to give us the needed military advantage." [85]

Keep Ahead of Growing Soviet Technical Threat. According to Dr. Martin:

> . . . [T]o offset Soviet numerical superiority on a continuing basis, we must maintain a technological edge. This is becoming increasingly difficult, given that Soviet RDT&E expenditures are about twice as large as ours, and more ominously, their training of scientists and engineers is proceeding at five times the rate of ours. In addition, the Soviets are acquiring significant amounts of Western technology, both by overt and covert methods.[86]

There are many sources of information about the technological and weapons balance between the United States and the Soviet Union published by the Defense Department, the State Department and the Central Intelligence Agency.[87]

In 1985 the chairman of the House Armed Services Committee released a report,[88] which concluded that although "Pentagon funding of basic technology rose 63 percent in real terms between 1980 and 1985 . . . there has been a technology decline based on the DOD's own comparisons of the relative Soviet-United States standing in 15 key military technology areas in 1980 and 1985." [89] The report said that although the United States still outperformed the Soviets in most militarily critical high-technology areas, it rated the United States as having fallen behind the Soviets in three militarily critical areas: microelectronic materials, electro-optical sensing, and submarine detection. In most areas the United States and the Soviet Union maintained the positions relative to each other that they had in 1980 (for most areas the U.S. led). The only area where the U.S. position was reported to have improved was radar sensing.[90]

In his *Annual Report to the Congress for the Fiscal Year 1987,* the Secretary of Defense described how Soviet investments in military R&D exceed those of the United States and the implications of this disparity for weapons imbalances:

> Soviet investment in military R&D has increased steadily in real terms for the past 20 years. Each year for the past decade the estimated dollar equivalent cost of their

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[85] Ibid.

[86] Ibid.

[87] See for example: Soviet Military Power, 1986, 5th ed., Washington, U.S. Govt. Print. Off. 1986.

[88] Aspin, Les. Defense Budgets Up—Whiter Security? What Have We Gotten For a Trillion Dollars? House Armed Services Committee, Washington, D.C., Oct. 7, 1985.

[89] Leopold, George. Pentagon Isn't getting Money's Worth in R&D. Electronics, Oct. 14, 1985, p. 21. (Press release.)

[90] Aspin, op. cit., figure 3. No change in ratings between 1980 and 1985 were reported in the fields of: aerodynamics/fluid dynamics, computers, directed energy, guidance and navigation, nuclear warheads, optics, manufacturing, propulsion, signal processing, materials and telecommunications.

> military R&D program has exceeded that of the United States. The Soviets are currently estimated to spend significantly more than what the United States spends for military R&D. In addition, the Soviets deploy approximately twice as many new and upgraded systems every ten years as does the United States. It should also be noted that this relentless Soviet buildup began from a very high base. We do not intend to "catch up" to the Soviets on a weapon-for-weapon basis. To do so would not only be inordinately expensive, but it would also be impractical. We do intend, however, to maintain the technological superiority that has served our strategy of deterrence so well.[91]

Ralph Sanders, who is a professor at the National Defense University, in a recent study described the competition in weapons technology between the Soviet Union and the United States. "The United States," he noted, "is 5 to 10 years ahead of the Soviets in many basic technologies such as micro-electronics, computers, and jet engines" and ". . . commands the lead in areas such as sea-based missile systems, fighter aircraft, and air-to-air missiles." [92] The Soviets are purported to excel in several scientific areas especially important to the military, including: "cryogenics, explosives, oceanography, high-pressure physics, and controlled atomic fusion." [93] According to Dr. Martin:

> The U.S.S.R. has long been superior in conventional warhead technology (including chemical explosives), and there has been relative technological parity in aerodynamics and fluid dynamics, directed energy, nuclear warheads and mobile power sources. In at least one of these areas, massive Soviet investment threatens to move them to a leadership position.
>
> The United States has a distinct lead in automated controls, computers, microelectronic materials and integrated circuit manufacturing, . . . aerospace propulsion, signal processing, signature reduction technology, telecommunications and the increasingly vital area of software. The lead can be preserved if guarded and futher nurtured. However, there are six key areas in which our current lead is slipping toward a U.S.-U.S.S.R. equality: (1) electro-optical and infrared sensors, (2) guidance and navigation, (3) optics, (4) radar sensors, (5) submarine detection and silencing techniques, and (6) high-strength, lightweight structural materials . . .
>
> The gap between United States and Soviet military technology capabilities has narrowed significantly during the

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[91] Weinberger, Caspar W. Annual Report to the Congress. Fiscal Year 1987, Department of Defense. Washington, U.S. Govt. Print. Off., 1986, p. 256.

[92] Sanders, Ralph. Introduction. In Franklin D. Margiotta and Ralph Sanders. Technology, Strategy and National Security. Washington, D.C., National Defense University Press, 1985, p. 7.

[93] The source of the data is attributed to John Collins, Library of Congress. As cited in Gannes, Stuart. The Soviet Lag in High-Tech Defense. Fortune, Nov. 25, 1985, pp. 108, 112. Among Dr. Collins' publications in this field are: Collins, John M.; Curtiss, Elizabeth; Friedmann, Tom A.; and Victory, Bernard C. U.S./Soviet Military Balance; Statistical Trends, 1976–1985 (as of January 1, 1986). Revised Apr. 3, 1987. Congressional Research Service, Library of Congress, Washington, D.C., 229 p. (CRS Rept. 87-128 S.)

> last decade as a result of inadequate research funding and inadequate and unenforced export controls have allowed Soviet access to much of our leading-edge defense-related technology. By providing adequate funding and exercising reasonable export control, this trend can be reversed.[94]

Some believe that the United States is widening its lead over the Soviets in the area of computer and software, a vexing problem for the Soviets since according to most experts, future comparative advantages in weaponry will depend in large measure on microelectronic components.[95] However, the view has also been expressed that the Soviets are developing a basis to overcome Western leadership in information technology:

> Some experts think the Soviets are gambling on highly experimental fields in the hope of leapfrogging the West. For example, several Western analysts believe that research institutes in Kiev and Moscow are among the world leaders in optical signal processing, which could eventually replace electronic circuitry in computers.[96]

Dr. Richard Wohl, a strategic defense consultant, says that the Soviets lead the United States in many critical military technology areas, especially related to computers and electronics:

> . . . The Soviet Union now leads the world in deploying powerful, compact nuclear reactors aboard various Soviet satellites; exceeds the U.S. effort in space-borne material processing—exploring the weightless, near-vacuum environment of a space vehicle to conduct experiments in fabricating micro-electronic crystals and materials to be used in infrared detectors, image arrays and radar/transmitter equipment processing qualities that cannot be duplicated on earth; are making "remarkable strides in computerized optical processing and optical data storage . . . are one of the "leading countries in the world in development of advanced military-oriented computer software/mathematical algorithms . . . are making a number of significant advances in: high-energy lasers, neutron beams, particle beams, and adaptive optics.[97]

Threats are also posed by the Soviets because of their practice of targeting certain Western technologies for espionage and literature searches, especially in the area of electronics.[98] The U.S. Government has published a study called *Soviet Acquisition of Militarily Significant Western Technology: An Update,* an analysis of Soviet military technologies whose development has benefited from the Soviet acquisition of Western technology and has identified research areas targeted by the Soviets for acquisition by the Soviets.[99]

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[94] Martin, Managing Science and Technology For the Future, op. cit. pp. 46–47.

[95] Gannes, Stuart. The Soviet Lag in High-Tech Defense. Fortune, Nov. 25, 1985: 107–108.

[96] Gannes, op. cit., p. 112.

[97] Weeks, Albert. Defense Expert Rejects "Myth" of a U.S. Technological Edge Over Soviets. New York City Tribune, June 3, 1985: 2.

[98] Ibid.

[99] [Central Intelligence Agency?] Soviet Acquisition of Militarily Significant Western Technology: An Update, Sept. 1985. Washington, U.S. Govt. Print. Off., 1985. 34 p.

There is also a view that the Soviets devote far more science and technology resources to military work than does the United States. One view is that the Soviet Union has "outspent the U.S. in R&D by about 50 percent over the past 11 years. . . ." [100] Thus some have concluded that "the Soviet Union has a 10-year lead and a significant funding momentum as an R&D advantage over the U.S." [101] Another estimate is that ". . . in the aggregate, U.S. scientists and engineers spend 25 percent to 30 percent of their time on military research." [102] But in contrast "at least 60 percent of qualified Soviet scientists and engineers work in the defense sector. . . ." [103] Of course the point could always be made that quality is more important than quantity when measuring Soviet and U.S. investments and outputs in science and technology. But in a 1982 study the Defense Science Board reported that the U.S. lead over the Soviet Union is rapidly eroding because of decreases in R&D funding and erosion of the U.S. scientific personnel pool [104]

### 2. ALLEGATIONS THAT THE UNITED STATES OVERREACTS TO THE SOVIET THREAT

Critics have charged the Pentagon with overreacting to purported Soviet strength. The point has been made that striving for technological superiority over adversaries can be destabilizing. As Franklin Long and Judith Reppy note:

> . . . [H]igh technology weapons tend to be expensive, so that the number of weapons that the U.S. can buy is often small. The other drawback is that constant introduction of new technology accelerates U.S.-U.S.S.R. competition, in that the Soviets can and almost routinely do ultimately develop the new technologies that the United States has first devised, leading the United States to feel the need to respond again. It is this process of action and reaction that constitutes an arms race, with the costs and uncertainties this implies.[105]

Some also claim that the United States-Soviet balance in technological strength is no guarantee of ultimate military superiority because:

> Technology is only one ingredient of military power, and not necessarily the most important. Its advantages can be obviated by poor leadership, bad planning, or inadequate training.[106]

In a recent report of the Brookings Institution recommendations were made to ". . . curb . . . many new exotic research programs and redundant weapons systems" which would result in saving $117.1 billion in projected budget outlays over the next four years while sustaining adequate readiness. The report's findings rest on the conclusions that:

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[100] Chadwell, Paul A. DOD and Service R&D Programs. National Defense: p. 44.

[101] Ibid., p. 47.

[102] Gannes, op. cit., p. 198.

[103] This is an estimate of Julian Cooper, a specialist in Soviet industrial technology at the University of Birmingham in England. As cited by Gannes, op. cit., p. 108.

[104] McIntyre, John. Defense Science Board Reports on the Technology Base. Defense Science, May/June 1982: 42, 44–45, 63.

[105] Long, Franklin A. and Judith Reppy. The Decision Process for U.S. Military R&D. In Kosta Tsipis and Penny Janeway, eds. Review of U.S. Military Research and Development, 1984. Washington, Pergamon-Brassey's, 1984. p. 5.

[106] Miller, Steven E. Technology and War. Bulletin of the Atomic Scientists, v. 41, Dec. 1985: 46–47.

> The Pentagon exaggerates Soviet military strength; underestimates the strength of the combined U.S. and allied powers; has adopted inefficient strategies; unnecessarily accelerates military programs of doubtful urgency; pays out excessive profits; and retains redundant military strategies.[107]

## D. MILITARY RESEARCH FUNDING MECHANISMS AND PROCEDURES

The DOD S&T programs are formulated using both a "top down" and "bottom up" approach to policy and priority setting. In summary, research (6.1) objectives are assessed and documented based on planning documents prepared by the research offices of the services, based on needs identified by military commanders, and in cooperation with the Services' R&D laboratories, scientific officers, and advisory panels, and through liaison with other Government agencies and information derived from scientific meetings, journal articles, previous research accomplishments, and intelligence information. In addition ". . . another generator of new ideas for the military is a group of not-for-profit establishments that are funded by the military services, but separately managed." [108] Priorities are determined generally by the scientific office in cooperation with the associated laboratories and, depending upon the service, with ancillary research organizations. These priorities are reviewed in a three tier process under the direction of the Deputy Under Secretary for Research and Advanced Technology.[109] As noted below a DOD reorganization was initiated in 1986, but has not been fully implemented yet. The position of Deputy Under Secretary for Research and Advanced Technology still existed as of March

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[107] Bedard, Paul. Liberal Think Tank Presents Alternative Defense Budget Formula. Brookings Would Kill Sub, Jets. Defense Week, May 19, 1986: p. 10.

[108] Long, Franklin A. and Judith Reppy. The Decision Process for U.S. Military R&D. In Tsipis, Kosta and Penny Janeway, ed. Review of U.S. Military Research and Development, 1984. Washington, Pergamon-Brassey's 1984, p. 4-19. On the role of the not-for-profit establishments in military R&D decisionmaking, see: A. Kossiakoff. Conception of New Defense Systems and the Role of Government R&D Center. In Long, F. A. and Reppy, J., eds. The Genesis of New Weapons. Decision Making for Military R&D. New York, Pergamon Press, 1980.

[109] This process was described in hearings before Task Force on Science Policy of the House Committee on Science and Technology, as follows:

"The S&T investment strategy of each Service is reviewed annually. [The Deputy Under Secretary of Defense for Research and Advanced Technology] chair[s] this review which covers: investment rationale, program technology thrusts, resource allocation (people and funds), and accomplishments. This review provides a top-down examination of S&T programs at the laboratory level."

"Science and Technology reviews are structured to provide a middle management review of the service's S&T programs in specific areas such as Materials and structures, Environmental Sciences, Computer Software and Systems, etc. These reviews are conducted by . . . office Directors. At such a review, mid-level managers from each of the Services present the S&T program content in the area with an emphasis on direction at the project level. Major attention is given to quality, program milestones, potential payoffs and technology transition."

"In-depth Topical Reviews of the Service's programs in focused areas are conducted as required. These reviews cover the DOD-wide effort in focused areas such as gun and missile propulsion, keg engines, electronic devices, chemical defense, etc. The reviews are conducted by staff specialists in [the office of the Deputy Under Secretary] and feature presentations by laboratory scientists and engineers on the technical programs in the particular area. These reviews provide an in-depth technical assessment of the area and are a valuable coordination tool." (Carter, Testimony, Oct. 5, 1985, op. cit., p. 12.)

1987.[110] However, now all RDT&E functions fall within the purview of the Under Secretary for Acquisition; the office of the Under Secretary for Research and Engineering was terminated. The newly created Director of Defense Research and Engineering manages the basic research program and serves as the scientific advisor on development programs to the Under Secretary for Acquisition.[111] The review process described above does not appear to have changed significantly with the reorganization.

The specific steps involved in the sequence from R to D have been detailed as follows:

> The procedures that lead to the initiation of a military R&D project routinely call for a standard sequences of steps carried out by a single military service, with review and approval at specific "milestones" by the Office of the Secretary of Defense (OSD). The main steps during the early phases of the development cycles are formally described as follows:
>
> —A statement of operational need by a military command;
>
> —In response, the formulation of a "mission element need" document, which typically calls for an R&D effort;
>
> —Validation by OSD of the requirement for a new development (Milestone 0);
>
> —Analysis (done by in-house groups and/or by contract with industry) of alternative ways of meeting the mission need;
>
> —Selection of a limited number of options to be pursued (Milestone 1);
>
> —Establishment of a project office to manage the new program; and
>
> —Selection of industrial contractors to perform the development.[112]

The Defense Systems Acquisition Review Council (DSARC) was established in 1969–1970 originally by David Packard when he was Deputy Secretary of Defense to bring together representatives of all concerned parties at important milestones in the development of a new weapons system. It was composed of: the Director of Defense Research and Engineering, who served as the chairman, and the Assistant Secretaries of Defense for Program Analysis and Evaluation; for Manpower, Reserve Affairs and Logistics; for International Security Affairs; and the Comptroller. DSARC was intended to decentralize decision-making by limiting OSD involvement in program management and by giving program managers authority to award funds below a certain threshold level without a DSARC review. In 1984 the threshold requirement was that ". . . all programs that are expected to cost more than $200 million for R&D or $1 billion [in 1980 dollars] in procurement go through DSARC review."[113] But in practice, according to Long and Reppy, ". . . the extensive briefings required before each DSARC meeting and the need for the program manger to be responsive to OSD concerns has facilitated continuous OSD input into program management, at least for important programs."[114] In 1978, the General Accounting Office concluded that the process was being implemented adequately.[115]

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[110] See The Department of Defense Statement on The Science and Technology Program by The Deputy Under Secretary of Defense for Research and Advanced Technology to the 100th Congress, First Session, March 1987, 41 p.

[111] Statement by Richard P. Godwin, Undersecretary of Defense for Acquisition Before the Research and Development Subcommittee, House Armed Services Committee, March 4, 1987, p. 4.

[112] Long, Franklin A. and Judith Reppy. Decision Making in Military R&D: An Introductory Overview. In Long, Franklin A. and Judith Reppy, eds. The Genesis of New Weapons. Decision Making for Military R&D. New York, Pergamon Press, 1980. p. 10.

After the establishment of DSARC ". . . each military service also established an in-service review council, the S/SARCs, which [were] . . . responsible for making recommendations to the service secretary on programs that are too small to qualify for full DSARC treatment. They also carr[ied] . . . out preliminary program reviews for DSARC milestones on the larger programs." [116]

As mentioned above, the DOD reorganization instituted in 1986 was intended to streamline the acquisitions management process and to establish a uniform acquisition organization.[117] The reorganization is still being implemented. According to the DOD, as of March 1987, the Under Secretary for Acquisition was being assisted by a Joint Requirements Management Board subsequently retitled the Defense Acquisition Board. The new board will provide oversight for program milestone reviews. Formerly about 126 committees and related bodies assisted in the acquisition process; this has been pared down to 10 operating committees. In addition, the program milestone review process has been modified to enhance planning and to "reflect valid mission needs."[118]

DOD's science and technology program priorities are coordinated internationally through various NATO groups, and domestically, through interagency agreement. According to Deputy Under Secretary of Defense for Research and Advanced Technology:

> In the interagency arena formal arrangements exist with other government agencies such as NASA and DOE in areas of mutual interest. Also, there are frequent contacts with the National Science Foundation, the National Academies of Science and Engineering and the university community. And, finally, as in the case of all organizations doing R&D, we are engaged in active sponsorship of and participation in symposia, conferences and meetings in the research and development field.[119]

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[113] Long and Reppy, Decision Process for Military R&D, op. cit., p. 14.

[114] Long and Reppy, Decision Process for Military R&D, op. cit., p. 14.

[115] Citations given by Long and Reppy are: Report to the Deputy Secretary of Defense, by the Acquisition Advisory Group, Sept. 30, 1975 (mimeo), v 1, p. 23. U.S. Comptroller General. A Critique of the Performance of the Defense Systems Acquisition Review Council; Billions in Public Funds Involved. PSAD-78-44, Jan. 30, 1978.

[116] Long and Reppy, Decision Process for Military R&D, op. cit., p. 14.

[117] Requirements were specified in the Goldwater-Nichols Act of 1986, the Authorization and Appropriations Acts of 1987, the Packard Commission recommendations. (See: Statement by Richard P. Godwin, Undersecretary for Acquisition before the Research and Development Subcommittee, House Armed Services Committee, 100th Congress, first session. March 4, 1987, pp. 1-2.)

[118] Godwin testimony, op. cit., pp. 5-8.

[119] Carter, Testimony, Oct. 2, 1985, op. cit., p. 13.

Each of the Services R&D priority setting mechanisms will be discussed next.

### 1. THE ARMY

The Army's research priorities are expressed in an annually prepared publication called "Science and Technology Objectives Guide" (STOG). This document, as well as the deliberations of the Army's Research, Development and Acquisition Council (RDAC), identify S and T base program objectives which are used in judging the relevance of proposals submitted by in-house and external scientists.[120] The Army strives to support a research program which totals about 5 percent of its total RDT&E budget level. The Army Research Office (ARO) focuses on disciplinary research and shapes its program in cooperation with the Army Training and Doctrine Command and its schools. An example of this, according to DOD, is increased research on chemical and biological warfare, resulting from joint planning by ARO, the Chemical Research and Development Center and the U.S. Army Chemical Schools.[121]

### 2. THE NAVY

In its extramural research program, the ONR generally awards contracts in response to unsolicited proposals. According to testimony of Marvin Moss, Director of ONR, before the Task Force on Science Policy, ONR issues two annual guidance documents that are relevant to the establishment of programmatic thrusts and priorities: the ONR Naval Needs Document and the Research Planning and Programing Guidance Document. The former is classified and summarizes long term naval technology requirements. The second highlights priority research topics from a variety of sources. ONR also receives advice from NSF and is ". . . establishing NAS panels for each . . . discipline" to provide reports on priorities.[122]

Scientific merit and relationship to military needs are important criteria in priority setting.[123] Naval research is coordinated with the National Science Foundation; medical research with the National Institutes of Health, and oceanographic research is coordinated with the National Oceanic and Atmospheric Administration and NSF. There has been created a Naval Studies Board at the National Academy of Sciences-National Research Council, sponsored by ONR. In 1986 the National Research Council of the National Academy of Sciences established an advisory committee to advice on long-range research opportunities in chemistry and other areas for the Navy and Marine Corps.[124]

### 3. THE AIR FORCE

To manage its basic research program, the Air Force Office of Scientific Research (AFOSR) prepares biennially a planning document to serve as a basis for the Air Force Plan for Defense Research Sciences. The planning guide, which represents "the combined counsel of the technical directors and program managers at the Air Force research and development laboratories," serves the scientific community by ". . . identifying the technology interests of the Air Force, to provide a prospectus of research objectives to which the scientific community can respond, and to document the relevancy of fundamental [research] to the Air Force mission." [125] The written guide, which is intended to generate unsolicited proposals from the scientific community, groups objectives into eight technical areas: life sciences, materials, geophysics, aerospace vehicles, propulsion and power, weaponry, electronics, and computational sciences. Utilizing this document, the AFOSR publishes periodic guides for researchers inviting proposals for research in disciplinary areas and identify points of contact to facilitate submission of proposals. The guides also identify collateral research programs, that is joint Air Force, university, and industry programs that support graduate education, encourage the development of centers of research excellence in critical technological areas and train quality research personnel. A recent document of this type is entitled *Research Interests of the Air Force Office of Scientific Research.*[126]

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[120] U.S. National Science Board. Basic Research in the Mission Agencies. Agency Perspectives on the Conduct and Support of Basic Research. Washington, U.S. Govt. Print. Off. 1978. p. 69.

[121] Department of Defense. Basic Research Program, Sept. 1985, p. 67-69.

[122] Testimony of Marvin Moss, Before the Task Force on Science Policy, House Committee on Science and Technology, Apr. 9, 1986. p. 2-3.

[123] Department of Defense. Basic Research Program, Sept. 1985, p. 71.

[124] Rawls, Rebecca. Promising Areas of Chemical Research Identified for Navy. Chemical and Engineering News, Feb. 24, 1986. p. 31-32.

In addition, each of the services publishes guidance for industry about their R&D needs and maintains facilities throughout the country to enable industry to identify defense R&D needs.[127]

### 4. CLUSTER PROGRAMS

Most of DOD's extramural research is supported via individual grants and contracts, but recently DOD increased its funding support for multidisciplinary "cluster" programs to focus on complex DOD problem areas. According to DOD

> These programs, which provide at least three years or more of stable support, are carried out by groups of researchers at universities each managed by a senior scientist. They serve essentially as program managers, providing clear direction and coordination. Examples of such programs are the tri-Service Joint Services Electronics Program (JSEP) and the Joint Services Optics Program (JSOP), in which ARO and AFOSR participate cooperatively in supporting major projects. Although JSEP is not new, this concept of research management is now being emphasized more strongly. Most cluster programs are funded by a single Service, with other Services and agencies participating in review. In 1976 only 25 programs (under JSEP and oceanography) were of this nature. Today there are

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[125] Air Force Systems Command Research Planning Guide (Research Objectives), Feb. 1, 1984. Washington, Andrews Air Force Base, various pagings.

[126] Research Interests of the Air Force Office of Scientific Research. Washington, D.C., Bolling Air Force Base, Nov., 1985. 66p.

[127] Tri-service industry information centers for information about acquisition, research and development are located in Alexandria Virginia, Pasadena California, and Wright-Patterson Air Force Base in Ohio. An example of a booklet describing technological and research requirements for the Marines Is: Search published by the U.S. Marine Corps Development and Education Command, Quantico, Virginia.

> many more. . . . [There are over 130 programs allocating over $150,000 each.] [128]

### 5. RESEARCH REVIEW PROCESSES

University researchers often prefer DOD research procurement processes to those of civilian agencies since DOD procedures are less tedious and time-consuming and require less paperwork for review. However, obviously researchers incur "costs" in freedom to choose research topics because DOD funds less "undirected" and more "targeted basic research." The largest civilian basic research funding agencies of Government, the National Institutes of Health, and the National Science Foundation, award research funds via grants to individual researchers, on a competitive basis. They rely extensively on external peer review, using a process of mail or panel peer review of solicited or unsolicited proposals. Each of these agencies also funds small amounts of contract work for the performance of specific tasks.[129]

Civilian agencies generally require an elaborate and time-consuming proposal writing and peer review process. But probably more often than in the civilian agencies, the military will encourage or discourage a researcher from submitting a formal written proposal after a telephone conversation about the merits of the research, thus saving the researcher's time; and, as a result, success rates for proposals submitted to the military often are higher than success rates for proposals submitted to civilian agencies.

The military research offices also appear to rely more on internal review (by agency personnel) than on peer review by the external scientific community. There are variations. The Air Force Office of Scientific Research (AFOSR) relies mostly on internal review, except for chemistry and mathematics, for which external peer review is used.[130] The Army Research Office (ARO) relies extensively on external peer review in addition to Army laboratory review for technical excellence and military relevance and an ARO internal review,[131] and the Office of Naval Research (ONR) relies mainly on internal review,[132] except for biological sciences, for which external peer review is used.[133] According to Dr. Marvin K. Moss, Director of ONR, "Academic peer reviewers cannot be expected to be knowledgeable about the Naval mission and its research implications." But ONR officers are encouraged to remain active in their disciplines so that they will retain their abilities to review proposals.[134]

### 6. CONTRACTING

Much military research is funded with a DOD-wide uniform one-page research contract, established in 1980. There are reports that the use of the contract reduces paperwork burdens and red tape and speeds up the time between proposal offer and contract award.[135] At the same time the Services probably have more control over the kind of work that can be performed than do civilian agencies.

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[128] Department of Defense, Basic Research Program, 1984, p. 4.

[129] National Science Board, op. cit., p. 95 and National Commission on Research. Review Processes: Assessing the Quality of Research Proposals. Washington, 1980. p. 5-6.

[130] National Science Board, op. cit., and National Commission on Research, op. cit., p. 6.

[131] Department of Defense, Basic Research Program, Sept. 1985, p. 69.

[132] Ibid., p. 71.

[133] National Commission on Research, op. cit.

[134] Testimony before the Task Force on Science Policy, Apr. 9, 1986. p. 2.

Recently there has been some controversy about the merits of sole source contracting and the burdens placed upon the military research managers as a result of the Competition in Contracting Act, (Title VII of P.L. 98-369). One view has been expressed that in order to retain a comparative advantage in research, the military should be allowed to award some research funds on a sole-source basis. For instance:

> More awards of *initial* R&D contracts should be done on a sole-source basis. Thus, unsolicited proposals would be encouraged for new ideas, and the individual or firm submitting them would have confidence that he would be able to begin the effort without competing (for his idea) with many of the large firms.[136]

The Competition in Contracting Act of 1985 was intended originally "to improve the efficiency and competition in DOD's procurement of hardware. . . ."[137] It also applied to contracting for basic and applied research. Generally, it requires all Federal agencies to use competitive contracting, but agency heads may, if necessary, exclude certain sources or maintain alternative sources of supply in the case of some kinds of research if to do so would be in the interest of national defense or would help in establishing or maintaining an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or federally funded research and development centers. (Sec. 303(1)(c)). In order to comply with the act, the Department of Defense and the Services publish formal solicitations in the *Commerce Business Daily.* Service research offices publish broad agency announcements, which outline the specific extramural research areas of interest and outline procedures to submit research proposals.

Compliance with defense research procurement regulations governing basic research and exploratory development has made the process a "nightmare" according to Robert S. Cooper, former Assistant Secretary of Defense and Director of the DARPA.[138] He charged that lead-times have been lengthened from 90 to 285 days from proposal submission to signing the contract and that there is a tremendous amount of paperwork and deterrence to close communication. He urged that Congress recognize the special nature of research procurement and change current laws to ease paperwork burdens and restrictions on defense research managers.

James A. Tegnelia, acting director of DARPA, criticized the statute for deterring creative work and possibly disclosing proprietary information:

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[135] Gamota, op. cit., p. 7 and Department of Defense, Basic Research Program, op. cit., p. 4.

[136] Gansler in Long and Reppy, 1980, p. 55.

[137] Testimony of James A. Tegnelia, before the Task Force on Science Policy of the House Committee on Science and Technology, Oct. 2, 1985, p. 4.

[138] Statement by Dr. Robert S. Cooper before the Science Policy Task Force, U.S. House of Representatives, Committee on Science and Technology, Oct. 23, 1985, p. 5.

> This legislation . . . has further increased an already lengthy proposal-to-contract cycle. This makes it more difficult for DARPA (and other agencies) to respond quickly to new opportunities, and discourages dynamic and innovative researchers from pursuing government research support. Clearly the purchase of or contracting for intellectual property (research concepts) is a matter quite different from that for manufactured radar systems or radar ranges. For example, publication of an intent to fund a research proposal to pursue a specific concept, so that others could bid if they have similar capabilities, can lead to the disclosure of proprietary information if an adequate concept description is published.[139]

Dr. Tegnelia recommended that the provisions of the act that allow for basic research to be selected competitively through "general solicitations" be extended. "Perhaps extension to exploratory development (6.2 funds in DOD budgetary terms) contracts up to some size, say $500,000, would alleviate this problem.[140]

Among Dr. Cooper's additional recommendations were the following:

(1) Change the laws and regulations controlling defense research contracting. Give it a special status and recognize its special needs;

(2) Reduce procurement lead times to 90 days maximum for contracts less than $2 million and 150 days for those between $2 million and $10 million;

(3) Accept abbreviated proposals and minimize required "boiler plate" appendixes to both proposals and contracts governing small scale research (less than $2 million).

(4) Accept the concept of "competition of ideas" as satisfying the government-wide goal of providing competition in contracting. Do not require, as a management practice, that any fixed percentage of research contracts be "competed" in the formal sense of the word but instead recognize the processes by which unsolicited proposals and sole source awards are made as legitimately satisfying the "competition" requirement;

(5) Simplify the reporting requirements for basic research; and

(6) Streamline financial audit procedures for small businesses and universities as they relate to basic research and exploratory development contracts.[141]

## E. ALLEGED INEFFICIENCIES IN MILITARY RESEARCH PLANNING

Despite the advantages conveyed by DOD's and the Services' formal decisionmaking processes, observers have detected substantial flaws in the processes and outcomes of R&D decisionmaking procedures. These include: possible inefficiencies caused by interservice rivalry, the need to link research priorities more to military and combat needs, and duplication to ongoing research efforts.

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[139] Tegnelia, testimony to ease paperwork burdens and restrictions on defense research managers, op. cit., p. 4.

[140] Tegnelia, op, cit., p. 4.

[141] Cooper, Testimony, Oct. 23, 1985, op. cit., p. 6-7.

### 1. POSSIBLE INEFFICIENCIES IN RESEARCH AND TECHNOLOGY DEVELOPMENT CAUSED BY INTERSERVICE RIVALRY

In 1965, two defense planners, Klaus Knorr and Oskar Morgenstern, concluded that more competition would spur military technological innovation. They gave as an example:

> An outstanding example of imaginative rivalry is the foundation of the Livermore Laboratory of the AEC. While important work on nuclear warheads was done at the Commission's Los Alamos Laboratory, some scientists were dissatisfied with the speed of acceptance of new ideas there and organized the new laboratory in order to let their ideas have free play. Out of the ensuing rivalry came the speedy development of the hydrogen bomb and of many other devices which might have become available only after much longer time-intervals.[142]

Economic pressures were observed in 1965 to have prevented ample ". . . opportunity for healthy rivalry in activities pertaining to R&D." [143] One way to overcome this rigidity and "the drag of vested interest, is in the insertion in the innovative process of talented outsiders—that is, for people who are not a regular part of the bureaucratic structure."[144] As examples of successful use of outsiders, Drs. Knorr and Morgenstern cited:

> One classic case of outsiders intervening in a decisive way was the famous Von Neumann Committee, which was organized at John von Neumann's behest and without which the United States would not have embarked on a missile program at a time when its success was highly dubious, both from a technical and from a military point of view. Another concerned the Polaris concept, which was made possible solely by the reduction of the weight of the warhead that could be put on a missile in a submarine, a fact that became known to its proponents only through the personal intervention of outsiders who realized what could be done. There was also Project Matterhorn, set up by J.A. Wheeler on his own initiative; it was a critical element in initiating the invention of the hydrogen bomb. There are more such cases though not all are as spectacular, but in their general effect they have been of very great significance.[145]

However, the disadvantages of competition, especially in the form of inter-service rivalry have also been widely noted. Franklin Long and Judith Reppy, long-time students of the DOD research funding process, have concluded that many parochial interests dominate R&D decisionmaking and that ". . . the separate military services with their own traditions and missions comprise a set of bureaucratic interest groups with competing definitions of the national interest." The result for military R&D is a reduction of ". . . support within the services for new systems that threaten to replace established missions and weaponry, and also to make difficult the cooperative development and deployment of jointly used systems such as communications." This is costly and impedes technological innovation and innovative solutions to military needs. Furthermore, they note that:

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[142] Knorr, Klaus and Oskar Morgenstern. Science and Defense. Some Critical Thoughts on Military Research and Development. Policy Memorandum no. 32. Center of International Studies, Princeton Univ., Feb. 18, 1965. p. 28.

[143] Ibid., p. 28.

[144] Knorr and Morgenstern, op. cit., p. 31.

[145] Knorr and Morgenstern, op. cit., p. 31-32.

> Jacques Gansler extends this point in his analysis, arguing that the oligopolistic structure of the U.S. defense industry reinforces the tendency of the military services to prefer incremental improvements in existing technological approaches for established missions. Technical elaboration by large engineering departments of the industry leads to overengineered and overly costly products. Further, the acquisition process itself, with its bias toward firms with previous experience and its elaborate requirements for reporting, adding, and record keeping, tends to exclude new firms, particularly small, innovative firms, from entering the defense market.[146]

Interservice rivalry can also lead to wasteful duplication. This problem is treated below.

### 2. POSSIBLE INEFFICIENCIES CAUSED BY PROBLEMS IN LINKING RESEARCH INVESTMENT TO MILITARY NEEDS

The Defense Science Board studied a related issue in its 1981 summer study, when it addressed questions raised by the Secretary of Defense about the status of the U.S. research and technology base necessary to cope with Soviet challenge. It reported:

> After reviewing the technology base planning strategies employed by the Services and DARPA, it was found that there was no consistent, DOD wide linkage between investment strategies and the requirements of future combat.[147]

The DSB panel recommended that an R&D investment strategy linked to combat needs be employed in DOD technology base planning ". . . so that technologies funded through the allocation process would be more explicitly and consistently related to future operational needs."[148] It identified 17 technologies for vigorous pursuit within DOD and within that list identified several for funding increases and for reorganization to "a vertically integrated program structure similar to the VHSIC program . . . ." As key elements of a vertically integrated program it specified: "centralized management and coordination of the total Tri-Service program with fenced funding to ensure accountability; the inclusion under one industrial organization of all aspects of a technology's development and transition into military systems [e.g., processes, design materials] and continuity of the industrial team(s) from early technology development through transition to system applications."

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[146] Long and Reppy, The Genesis of New Weapons. Decision Making in Military R&D: An Introductory Overview, in Long and Reppy, op. cit., p. 10-11.

[147] McIntyre, John. Defense Science Board Reports on the Technology Base. Defense Science, May/June 1982. p., 42, 44-45, 63.

[148] Ibid., p. 44.

It was recommended that several technologies receive funding increases and/or improved management, including: such basic electronics technologies as advanced software/algorithm development, microprocessor-based personal learning aids, fail-soft/fault tolerant electronics; rapid solidification technology, machine intelligence, supercomputers, advanced composites, radiation hardened advanced electronics, space nuclear power, high power microwave generators, large space structures, and short wavelength lasers.[149]

The DSB also identified several programs which should be deemphasized because of duplication with NASA (e.g. remote sensing, propulsion); overexpansion of DARPA programs into areas which overlap with other major DOD/Service programs (e.g., forward swept wing, VLSI, fiber optics); nonproductive duplication of the generic technology base by the three Services; and in-house execution of the basic research program . . . .[150]

The report also focused on the issues of transition of technology from research to weapons or product, the quality of university research infrastructure, the need for more funding for fellowships and upgrading of university computer facilities and research equipment, the status of DOD laboratories and the functions of DARPA, [151] and made recommendations to improve them.

The 1983 report of the Grace Commission, more formally known as the President's Private Sector Survey on Cost Control, also found that the Services may be reluctant to follow-through on projects started by DARPA, and that the Services and laboratories do not always effectively share data.[152]

### 3. ISSUES RELATING TO ALLEGED DUPLICATION IN RESEARCH

Duplication of research by the services can serve usefully to verify research results and as a competitive incentive intended to ensure the conduct of needed research. However, the Department of Defense has been concerned about excessive duplication in research contracts. An audit conducted by DOD between April and November 1984 "shows that duplicated research has wasted about $32 million dollars . . . "despite a directive that its 73 research laboratories search a DOD data base to ensure that proposals don't merely reproduce existing projects." It should be noted that this constitutes only about .1 percent of total RDT&E spending, which some might perceive as insignificant duplication. Others say this study examined only the tip of the iceberg. The audit also ". . . found that many research contracts either lacked documentation showing a military purpose or were irrelevant." In addition the audit showed that the data base was incomplete because ". . . 37

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[149] McIntyre, op. cit., p. 44.

[150] McIntyre, op. cit., p. 44.

[151] Ibid., p. 63.

[152] President's Private Sector Survey on Cost Control. Task Force Report on Research and Development, Nov. 1983, as cited in Waste in the Defense Department, op. cit., p. II-8.

percent of research contracts and 58 percent of the resulting technical reports were not reported. . . ." [153]

These issues were discussed at hearing held by the House Government Operations Committee in September 1983 on research duplication.

> In its report to Congress on the Defense Authorization Act for FY 1985, which reduces the President's request by $19.5 billion . . ., the House committee said the "Office of the Secretary of Defense continues to avoid the important decisions that would provide the United States a greater return on its defense investment in research and technology." It said the duplication of effort and an absence of joint programs continues to exist. The committee specifically zeroes in on the Joint Tactical Missile Systems (JTACMS) and the Joint Surveillance Targeting and Radar System (JSTARS) programs.[154]

In addition, the Congress was concerned with applying the results of research investments: "Unless the Department of Defense reduces the number of ongoing programs and transitions some technological advances in microelectronics and computers into 'military useful systems," the committee added, "the Congress has little choice other than to manage more defense programs than necessary or desirable." [155]

In a 1985 report entitled *Waste in the Defense Department,* it was concluded that the DOD could save about $2.9 billion per year by improving coordination among the branches of the military and improving strategic planning for defense R&D.[156] The President's Private Sector Survey on Cost Control, (the Grace Report) Task Force Report on Research and Development of November 1983, reported that "at least a ten percent savings in the Defense Department's R&D budget could be achieved by strategic planning of R&D. . . ." [157] The Grace Report attributed considerable inefficiency to the fact that the Services "plan almost autonomously and frequently at cross-purposes with little direction provided by the Under Secretary of Defense for Research and Engineering . . . or the Office of the Secretary of Defense. There are relatively few joint programs, even though their tactical requirements often demand essentially the same R&D." [158]

In addition, in a report released in 1985, the Georgetown Center for Strategic and International Studies reported that the absence of effective "cross-service" advice on weapons development is hampered by each Service's attempts, via the deliberations of the Joint Chiefs of Staff, to maintain the status quo and its position. Each Service was said to develop its own munitions independently. "As a result, the panel reported, weapons of 'questionable value' to strategic goals often are produced despite poor performance and excessive costs." [159]

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[153] Audit Aims to Tighten Research Rules. Electronics, v. 59, Jan. 20, 1986: 20. The study continued: "Although audit results form all three service branches showed issuing documentation, Navy labs appeared to have the worst record: only 3 of 18 Navy research contracts studied included evidence of the required literature searches. In addition, the report singles out two contracts awarded by the Naval Research Laboratory that duplicated pervious Air Force research. The contracts, worth a total of $343,000, were awarded by the Washington labs in 1981 and 1982 to investigate failure mechanisms in gallium arsenide FETS. The Air Force Rome Air Development Center, Rome, N.Y., did the same research in 1978, the audit notes."

[154] House Panel Hits Pentagon for Lack of RDT&E Direction. Defense Daily, May 2, 1984: p. 9-10.

[155] Ibid.

[156] Kilgallon and Associates. Waste in the Defense Department, Washington, D.C., 1985. 215 p. (Prepared for the National Marine Engineers Beneficial Association.)

[157] Waste in the Defense Department, op. cit., p. II-5.

[158] Waste in the Defense Department, op. cit., p. II-6, citing, the Grace Report, p. 13.

In its report on the fiscal year 1987 authorization for the Defense Department, the House Armed Services Committee criticized Service duplication in the area of C3I and electronic warfare, and cut some duplicate research. For instance, it authorized $48 million of a requested $745 million for C3I in tri-service programs.

The committee also warned about the escalating investments in R&D and the future resulting "mortgage" of obligations. "The committee said every R&D dollar spent on advanced development and full-scale engineering generates a requirement of $10 or more within a five/year span for procurement and support costs." [160] This same point has been made in congressional authorizations deliberations over the years.[161]

However, it should also be noted that recommendations have been made to further decentralize research decisionmaking. In testimony before the House Science and Technology Task Force on Science Policy, Robert S. Cooper, former director of DARPA urged that complex formal decisionmaking processes that are too time consuming should not be used to fund basic research and exploratory development. He also concluded that "the long approval chain required by the military departments for program changes and the management system's intolerance of opportunity reserves within the budget must be changed." [162] He urged that DOD:

> (1) Further decentralize the management of research funds making the offices of scientific research in the military departments less dependent on headquarters for detailed approvals;
>
> (2) Consider setting up small highly capable technical management organizations for the advanced technology demonstration (6.3A) accounts in each service; and
>
> (3) Set a goal of 10 percent opportunity reserve in the research and exploratory development accounts at the beginning of the budget year and protect these reserves from raids by headquarters staff throughout the year.[163]

Another factor contributing to waste and duplication is the lack of coordination among the DOD laboratories. According to the report *Waste in the Defense Department:*

> Poor coordination among the 75 DOD laboratories which provide scientific and technical support to research and development activities has been a particular concern of both the Defense Science Board and the Private Sector Survey.

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[159] Weisskopf, Michael. Defense Buying System and Command Faulted. Washington Post, Feb. 26, 1985: p. A7.

[160] Pentagon Research Plans Assailed. Defense Week, Aug. 4, 1986.

[161] Battista Calls for Revamping DOD RDT&E Methodology. Defense Daily, Jan. 30, 1986: 158-159.

[162] Cooper, Testimony Before the Task Force on Science Policy, Oct. 23, 1985.

[163] Ibid.

> The laboratories administer most of the basic research and exploratory development, about 14 percent of the DOD R&D budget. The lack of coordination is such that the Defense Science Board describes the laboratories as "competitive and antagonistic in cooperative ventures and working at cross purposes." [164]

Enhanced coordination among the laboratories could save about $725 million, according to the report.

The same report noted that the Defense Science Board ". . . also identified some specific areas where lack of coordination has impaired the effectiveness of defense R&D spending." Specifically:

> There is duplication with the National Aeronautics and Space Administration, an overexpansion of Defense Advanced Research Projects Agency (DARPA) programs into areas that overlap with major Defense Department or services programs, and non-productive duplication of generic technology base research by the three services. [165]

## F. ADDITIONAL ISSUES CONCERNING THE CONDUCT AND UTILITY OF MILITARY RESEARCH

Among the issues covered in this section are: the alleged need for more long-range defense research, multiyear funding, the "high-technology" vs. "low-technology" debate, changes recommended for DARPA, and creation of an Under Secretary for Acquisition and termination of the Under Secretary for Research and Engineering.

### 1. IS THERE A NEED FOR MORE LONG-RANGE DEFENSE RESEARCH

The argument has often been made that more attention should be given to long-range defense research because ". . . long-range defense R&D represents a crucial investment toward preserving a margin of safety in deterrence, assuring reliable arms controls, and maintaining a credible capability for flexible responses to tactical conflicts that the U.S. cannot ignore." [166] This, in essence, is related to the complaint that 6.1 research has not grown as quickly as 6.2–6.6 RDT&E.

Research policy in the Department of Defense has been affected by another issue: that of how to best ensure the production of cutting-edge research that spurs innovation of military technology. Some have noted that the military laboratories do not do cutting-edge research work. However, there are notable exceptions such as Dr. Jerome Karle of the Naval Research Laboratory who won a Nobel Prize in chemistry in 1985.

Other related policy issues are:

How much DOD research should be pursued in-house, and how much extramurally? "The simple criterion of where can the work be done best is complicated by pressures to maintain certain inhouse capabilities. Pressures also exist to maintain viable capabilities in industry as well. . . . In-house laboratories on occasion develop vested interests in certain kinds of work which they guard very jealously." [167]

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[164] Waste in the Defense Department, op. cit., p. II.7, citing Defense Science Board. Report of the Defense Science Board, 1981 Summer Study Panel on Technology Base. Office of the Under Secretary of Defense for Research and Engineering. Washington, D.C., Nov. 1981. p. iv-4.

[165] Waste in the Defense Department, op. cit., p. II-8, citing Report of the Defense Science Board, 1981 Summer Study Panel on Technology Base, p. i-3, i-4.

[166] Seitz, Frederick and Rodney W. Nichols. Research and Development and the Prospects for International Security. National Strategy Information Center, Inc., New York, Crane, Russak & Co., Inc., 1973. p. 46.

A related and perennial issue is the length of time between research to product acquisition. In a report of its 1977 summer study, the Defense Science Board concluded that:

> "over the past 15-20 years the acquisition process—from initial program concept to initial operational capability—has increased in length by approximately 5 years on the average," and the board identified a number of planning and procedural problems which plague the U.S. effort.

The Board said it believed that the stages before the development phase take much longer than previously.[168]

Addressing this point in an interview in 1985, Admiral Bobby Inman, former director of the National Security Agency complained that during the 1950s and 1960s there was an average "gestation" period of four to five years between research and development and production. Now that period has increased to "roughly a dozen years." He urged that more attention be given to the criterion of speed in delivering products.[169]

Jacques Gansler also argues that more R&D should go to "the early stages of the R and D process" to overcome the potential for Soviet technological surprise and "the tendency of U.S. defense decisionmakers to spend less money on advancing critical, new components and materials from which radical technological departures would emerge.[170] Gansler also called for more R and D to focus on programs to lower costs and to fund multiple high risk projects at sufficiently high levels to recognize the risks involved.[171]

### 2. MULTIYEAR FUNDING

The recommendation has also been made that "there ought to be far more long-term stability as a primary consideration in R&D work. . . . One way of assuring this is through far greater use of multi-year funding.[172] The President's Private Sector Survey on Control also endorsed multiyear funding for research and development.[173]

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[167] Landis, Lincoln and Kendall W. Simmons. Science, Technology, Research and Development. Washington, D.C., Industrial College of the Armed Forces, 1974. p. 81, 82.

[168] Long, Frank A. and Judith Reppy. Decision Making in Military R&D: An Introductory Overview. In Long, Franklin A. and Judith Reppy. The Genesis of New Weapons. Pergamon Press, 1980, p. 14, 15, citing a U.S. Department of Defense, Defense Science Board. Repor. of the Acquisition Cycle Task Force, Mar. 15, 1978. p. 1-4.

[169] Healy, Melissa. United States Must Speed Up R&D, Says Inman. Defense Week, July 29, 1985: 16.

[170] As cited by Sanders, op.cit., p. 13.

[171] Gansler, Jackques. The U.S. Technology Base: Problems and Prospects. In Margiotta and Sanders, op. cit., p. 126-127.

[172] Gansler, Jacques. The Defense Industry's Role in Military R&D Decision Making. In Long, Franklin A. and Judith Reppy. The Genesis of New Weapons. Pergamon Press, Inc., 1980. p. 54.

[173] President's Private Sector Survey . . . Research and Development, p. 57, as cited in Waste in the Defense Department, op. cit., p. II-8.

### 3. CHANGES RECOMMENDED FOR DARPA

Dr. Gansler suggested that to enhance advanced R&D, each service should develop an organization like DARPA devoted to nontraditional research purpose.

> Essentially this organization would be an entrepreneur who would be an advocate within the Service to exploit the military opportunities offered by nontraditional applications or technological advances. Naturally, such an organization would need a "sponsor" within the office of the Secretary of Defense . . . [and] . . . a share of the DOD R and D budget . . . perhaps 5 percent of a service's R and D budget. . . .[174]

A blue-ribbon panel headed by former deputy defense secretary David Packard made several recommendations during early 1986 to improve procurement and management of R and D.[175] The commission noted that more prototype testing should be done at the early stages of R and D and that duplication among the services " 'disfavored new ideas and systems.' "[176] It recommended among other things that ". . . the Defense Advanced Research Projects Agency do more hardware development and prototype testing . . ." [177] It also recommended that:

> Key decision-making power [be handed] to a committee cochaired by a new under secretary of defense for acquisition and a new vice-chairman of the Joint Chiefs of Staff, with substantial, direct input from commanders in the fields. In this manner, the panel seeks to encourage the use of more off-the-shelf items and the development of more realistic specifications for new weapons.[178]

### 4. TERMINATION OF THE OFFICE OF UNDER SECRETARY FOR RESEARCH AND ENGINEERING

The Packard report also recommended that the Under Secretary for Acquisition should ". . . set overall policy for procurement and research and development (R&D), supervise the performance of the entire acquisition system, and establish policy for administrative oversight and auditing of defense contractors."[179] Legislation enacted during 1986 abolished the Office of Under Secretary of Defense for Research and Engineering and replaced it with the Under Secretary of Defense for Acquisition and re-established the position of Director of Defense Research andf Engineering. See chapter III above.[180]

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[174] Gansler, op. cit., p. 125.

[175] A Quest for Excellence. Final Report to the President by the President's Blue Ribbon Commission on Defense Management, June 1986. Washington, D.C., U.S. Govt. Print. Off., 1986. p.6.

[176] Packard Panel Urges Reforms. Science, v. 232, Apr. 25, 1986. p. 445.

[177] Ibid.

[178] Packard Panel Urges Reforms. Science, v. 232, Apr. 25, 1986. p. 445.

[179] A Quest for Excellence, op. cit., p. xxvi.

[180] See also: U.S. Congress. House. Committee of Conference. Goldwater-Nichols Department of Defense Reorganization Act of 1986. Conference Report to accompany H.R. 3622. 99th Cong., 2d Sess. H. Rept. 99-824. Washington, U.S. Govt. Print. Off., 1986. p. 6, 102-103.

### 5. THE "HIGH-TECHNOLOGY" VS. "LOW-TECHNOLOGY" DEBATE

There is also a debate about "high-technology" vs. "low-technology" weapons in the military, a debate fueled perhaps by many complaints, including the breakdown of the aircraft used in the aborted mission to rescue Iranian hostages in April 1980 and, in part, by the "Spinney" report, which challenges DOD's approach to using high technology in current warfare. It is often asserted that low technology made significant differences in military history, for instance:

> . . . by attaching auxiliary fuel tanks to fighter aircraft during World War II, the Air Corps gained escort fighters that could protect bombers conducting deep raids into Germany. Even something as simple as improved packaging for food rations extended the range over which soldiers could fight.[181]

The argument is made that low technology rather than high or extremely sophisticated technology, operates more efficiently and dependably, enables military forces to operate best at levels most suited to the low level of expertise of today's soldiers, and that high technology has excessive operational and maintenance requirements.[182] This may explain why some parts of the armed services are reluctant to adopt sophisticated new high technologies.[183]

Nevertheless, the counterargument is often made that sophisticated high technologies are necessary to enable the United States to overcome the numerical superiority of Soviet conventional forces and the Soviet push to develop and use sophisticated new technologies. Technology gaps between the United States and the Soviet Union have been discussed in both general and specific terms. According to SAC commander Bennie L. Davis:

> . . . The Soviets have taken a different approach than we in modernizing their strategic forces. They have employed state-of-the-art improvements in a relentless program to upgrade their weapons systems over the past two decades. As a result, while the bulk of our weapon systems is between 15 and 20 years old, the majority of theirs is less than 5 years old. . . . This trend must be reversed. Our projected strategic modernization programs will suffice for the near-term. For the longer term, the lead times for new weapons-system deployments cannot continue to grow or we will be confronted with a paradoxical no-win dilemma. The rapidly accelerating "technology wave" will compress the time available for incorporation of new developments. If lead times are not shortened to keep apace, we may lose the flexibility and hedging inherent in our strategic Triad

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[181] Sanders, Ralph, Introduction, p. 11, discussing Irving B. Holley, Technology and Strategy: A Historical Review. In Margiotta, Franklin D. and Ralph Sanders, eds. Technology, Strategy and National Security. Washington, D.C., 1985.

[182] See also: Chapter 10. Deitchmann, Seymour J. Military Power and the Advance of Technology. General Purpose Military Forces for the 1980s and Beyond. Boulder, Westview Press, 1983.

[183] Sanders, Introduction, op. cit., p. 1-2, discussing an article: by Franklin D. Margiotta and Michael Maccoby, Future Challenges to Military Leadership: Adjusting to the Human Implications of Advanced Technology, in Margiotta and Sanders, op. cit.

> and forfeit the margin of safety necessary to maintain stability in the next century.[184]

The fundamental issue in the debate then in how and how much high technology or advanced technology should be integrated into U.S. military operations. The major issues in the debate were summarized by Walter Kross in 1985:[185]

> Is there a basic flaw in U.S. defense planning that overemphasizes high-tech weapons?
>
> How well does the present emphasis on high-tech weapons square with the realities of threats and budgets?
>
> How do high-tech weapons influence our doctrine, strategy, tactic and force structure?
>
> Do high-tech weapons inevitably lead to too much complexity?
>
> Are today's high-tech weapons too complex? Are too many weapons too complex? Are they too costly? How questionable is their effectiveness?
>
> Are the alternatives practical, attainable, and more effective?

Ancillary policy issues are:

> Does the focus on "high technology" research consume resources that might otherwise be used for research on other promising, but "low-technology" issues?
>
> Does a focus on "high technology" research commit budget funding in advance to "high technology" areas that will continuously need to be updated, thereby consuming large amounts of research dollars? Does this pattern, in effect, mortgage the future of the DOD research support program?
>
> Does a commitment to considerable amounts of "high-technology" research in effect put too much money in one pot, so that our adversaries know all our defense in advance?
>
> Is the low tech/high tech distinction a meaningful one, or is it a surrogate for something else?

## G. Concluding Observations

A large, complex and sophisticated system has evolved to fund and manage the science and technology needs of the defense community. The structure is flexible, expensive, bureaucratic, and subject to both praise and criticism. Military funding for basic research and for "technology base" science and technology research efforts is less today, in terms of constant dollar funding, than it was in the mid-1960s, when there began a decline, in constant dollars, in funding for "technology base" research that has not been restored. Questions have been raised about whether or not this is an adequate level of support given the long-lead time required to conduct the research necessary to develop technology to maintain national strength and security. It is acknowledged that Soviet scientific and technical capabilities surpass U.S. capabilities in some areas of research which are crucial to military superiority. Announced efforts over the years by DOD research chiefs to allocate increased minimum percentage of the DOD budget to the support of basic research have not been implemented. In addition, critics question recent moves to give the DARPA additional responsibilities in prototype development and testing, functions, which, it is charged, detract from DARPA's original mission to support cutting-edge research. Recently the Department of Defense was reorganized and the long-standing office of the Under Secretary for Research and Engineering was abolished. Created in its place was the Under Secretary for Acquisition, which now has responsibilities for all acquisition, including research and development. A reconstituted office of the Director of Defense Research and Engineering now reports to the Under Secretary for Acquisition. Some question whether such a move will ultimately jeopardize the Department's 6.1 research support efforts.

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[184] Davis, Bennie, op. cit., p. 58–59.

[185] Kross, Walter. Military Reform. The High-Tech Debate in Tactical Air Forces. Washington, D.C., National Defense University Press, 1985. p. 11.

University research performers appear to prefer military research procurement methods because they require less paperwork, and are more timely and less time-consuming than methods used by other agencies. However, some DOD officials recently have begun to complain that procurement of research should be treated differently from procurement of other goods and services and therefore should be exempt from more of the requirements of the recently enacted Competition in Contracting Act.

Problem areas which continue to dominate debates about military research priorities focus on:

—Better coordination of research funding among DOD and other Federal research support agencies;

—Duplication and lack of cooperation among the Services' research support activities;

—Questions about relevance and the possible need to link research priorities more closely to military needs;

—The need for more long-range research;

—Continuing debates about the relative merits of research and development for "high-technology" vs. "low-technology" weapons and systems, especially considering the limited technical capacity of most current military volunteers and the difficulty of making "battlefield" repairs to highly-complex technical systems;

—Proposals to decentralize research management and to create "DARPA like" research support structures for the Services; and

—The merits of multiyear funding for research and development.

# CHAPTER V

# DOD SUPPORT FOR RESEARCH AT COLLEGES AND UNIVERSITIES*

## A. INTRODUCTION

This chapter traces the role the Department of Defense (DOD) has played in supporting research and development (R&D) at the Nation's universities. The chapter begins with a historical review of military support of university R&D. It is noted, for example, that DOD was the Federal agency that organized many of the fundamental mechanisms currently associated with Federal support for academic research.

The chapter points out that during the 1950s and early 1960s DOD was the dominant Federal supporter of academic research, providing 41 percent of all Federal R&D funds to universities in 1958. However, by the late 1960s, with strained DOD university relations and the establishment and growth of such Federal R&D agencies as the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration, the military's university based R&D dominance was significantly reduced.

By 1975, universities received only 8 percent of all their Federal R&D funds from the Department of Defense. However, President Jimmy Carter's new Secretary of Defense, Harold Brown, quickly moved to reverse that DOD R&D funding trend of the previous decade. Both Secretary Brown and President Reagan's Secretary of Defense, Caspar Weinberger stated that the Soviet Union's accelerated development and modernization of its military technology required a resurgence of DOD support of academic R&D. Consequently by 1985, the military had doubled its share of university R&D support, providing 16 percent of all Federal R&D funding. Along with increased funding for R&D, this chapter also highlights recent DOD programs, aimed at helping the universities improve their research infrastructure.

Finally, the chapter reviews some past and present criticisms, problems and issues associated with military sponsored research on the Nation's campuses. Such recent issues as secrecy, the Strategic Defense Initiative, brain drain, DOD's dominance of research funding at universities in certain fields of science, and DOD's recent surge of development funding at the nation's universities are discussed.

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## B. Postwar History

Since World War II, the Department of Defense (DOD) has played a major role in supporting research at the Nation's colleges and universities. Prior to that war military support for research at colleges and universities was essentially nonexistent. During the war, primarily through the Office of Scientific Research and Development (OSRD), the universities performed research tasks in nearly every field of science and engineering, for both the Government and the military.

With termination of the war, scientists, Government officials and the Department of Defense felt that universities could play a crucial role in helping to prevent future conflicts by developing the Nation's science and technology base through: (1) the conduct of basic research for the discovery of knowledge and (2) education of future scientists.

Within the Department of Defense, the Navy was the first to appreciate the contribution university research could make in helping them to achieve their mission. Consequently, in 1946, the Navy established the Office of Naval Research (ONR). The Army established the Office of Ordnance Research in 1951, which was restructured in 1961 as the Army Research Office, ARO. The Air Force established in 1951 what is now the Air Force Office of Scientific Research (AFOSR).

The ONR was established to support basic and applied research in a variety of fields and to keep the Navy in close contact with basic scientific research being conducted within industry and the universities. The Office of Naval Research proved to be a true pioneer in supporting research at the Nation's universities.

The ONR was the first Federal agency to set aside substantial funding for research at universities. In fact, by 1950, the ONR was supporting over 40 percent of U.S. basic science. It developed a number of mechanisms which are still used today to support research at colleges and universities. They include:

Funding project grants for individual researchers at colleges and universities;

Establishing a peer review process to evaluate research proposals;

Purchasing of expensive specialized equipment;

Funding for the construction of large facilities, operated by a consortium of universities;

Funding for building laboratories at individual universities, with the research agenda set by the laboratory director; and

Funding for special purpose research institutions such as Woods Hole Oceanographic Institute.[1]

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[1] U.S. Congress. House. Federal Research and Development Programs. Select Committee on Government Research. Hearings, Nov. 18, 1963. p. 33.

### TABLE 5.1.—PERCENTAGE OF FEDERAL R&D OBLIGATIONS TO COLLEGES AND UNIVERSITIES FROM DOD

[In millions of dollars]*

| Year | Total Federal obligations | DOD R&D obligations | Percent DOD |
|---|---|---|---|
| 1958 | $288 | $118 | 41 |
| 1960 | 459 | 154 | 34 |
| 1965 | 1,192 | 291 | 24 |
| 1970 | 1,476 | 216 | 15 |
| 1975 | 2,411 | 203 | 8 |
| 1980 | 4,263 | 495 | 12 |
| 1985 estimate | 6,405 | 995 | 16 |

*Unless otherwise indicated, all data are from Federal funds for Research and Development Detailed Historical Tables: 1955-1986 and Federal Obligations for Research to Universities and Colleges by Agency and Detailed Field of Science: 1973-1986. Division Science Resource Studies.

### TABLE 5.2.—PERCENTAGE OF FEDERAL BASIC RESEARCH OBLIGATIONS TO COLLEGES AND UNIVERSITIES FROM DOD

[In millions of dollars]

| Year | Total Federal obligations | DOD obligations | Percent DOD |
|---|---|---|---|
| 1958 | $126 | $56 | 44 |
| 1960 | 237 | 75 | 32 |
| 1965 | 634 | 132 | 21 |
| 1970 | 808 | 127 | 16 |
| 1975 | 1,261 | 106 | 8 |
| 1980 | 2,320 | 208 | 9 |
| 1985 estimate | 4.022 | 453 | 11 |

The Pentagon also initiated support for indirect costs of conducting research for such things as building heat, light, and maintenance, telephone and secretarial services, accounting costs and research administration cost.

In terms of funding, the Department of Defense dominated Federal research and development support from the early 1950s into the mid-1960s. In the period from 1956–59, the DOD supported annually on the average, 74 per cent of total Federal R&D and R&D plant obligations.[2] The rapid rise of Federal R&D obligations between 1956 and 1959 (27.4 percent on an annual average in constant dollars) was primarily due to the DOD's growth in support for research and development.[3]

DOD also dominated Federal support of R&D at colleges and universities in the late 1950s and early 1960s. As tables 5.1 and 5.2 indicate, in 1958, DOD sponsored 44 percent of total Federal R&D performed at the Nation's universities and 41 percent of all the basic research that was performed at colleges and universities. DOD's support for basic research at colleges and universities jumped from $56 million in 1958 to $132 million in 1965 an increase of 136 percent. Meanwhile, DOD university support for R&D increased 145 percent, from $118 million in 1958 to $291 million in 1965.

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[2] The DOD Share in Federal R&D Funding, in Federal Funds for Research and Development Fiscal Year 1980, 1981, and 1982. v. XXX, NSF 82-321. p. 15.

[3] Ibid., p. 15.

Although the level of funding from DOD to the Nation's universities was increasing dramatically in the late 1950s and early 1960s, DOD's dominance in Federal support for university research had already begun to decline. The rapid build-up of research programs in the Atomic Energy Commission (AEC), the National Institutes of Health (NIH), and the National Science Foundation (NSF), quickly reduced the overall percentage of DOD research support at colleges and universities. As table 5.1 shows, DOD's overall support for basic research at colleges and universities declined to 24 percent of the total in 1965.

By 1966, DOD had dropped to third (HEW and NSF were higher) in terms of funding for basic research at the Nation's universities. Nevertheless, DOD still considered its research participation at colleges and universities essential to its overall mission. For example, in 1966, 54 percent of DOD's basic research was performed at universities. The importance of this objective was amplified in a 1963 Defense Science Board report on DOD research policy. The report indicated that close DOD university relations were essential for the following reasons:

> (1) The success of the development, testing and evaluation programs supported by the Department of Defense still depends . . . on . . . the quality of the basic research being performed throughout the country;
>
> (2) Through the support of basic research, the Department of Defense should see that scientists and engineers in government laboratories maintain some degree of direct association with those engaged in similar research for industry and the universities;
>
> (3) The Department of Defense and its contractors will need, to an ever increasing need, the most highly trained scientists and engineers our educational institutions can provide; and
>
> (4) The extent to which scientists and engineers know about defense . . . the DOD will find it easier to recruit them for permanent or temporary staff positions. . . .[4]

## C. DOD's Reduced Role

Despite this growing partnership between DOD and universities, by the mid-1960s, tensions began to develop on the campus and within the academic research community itself. As the Nation's sentiment began to shift in opposition to the Vietnam war, faculty and student criticism of DOD sponsored research on the college campuses intensified and the relationship between DOD and academia began to unravel.

Specifically, many faculty and students said that universities had three primary functions to perform and that the strong presence of DOD-supported research on the Nation's campuses compromised these functions. Essentially, the three functions were: first, to support fundamental research drawing out nature's secrets and creating new knowledge; second, teaching and educating the Nation's youth to make use of this new knowledge; and third, service to society as a whole to assist in finding solutions to the problems of society. Many of the faculty and students contended that military research, especially classified research, was essentially inconsistent with these functions, especially the need to help solve societal problems. Critics of military sponsored research argued that more money should be spent on civilian problems:

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[4] Report of the Defense Science Board Subcommittee on Dept. of Defense Research Policy. Part I. Policy on Support of Basic Research. Dec. 31, 1963. p. 2.

> Half of all U.S. research and development is military in nature. Last year (1968), the United States spent four times as much on chemical and biological warfare as it did on cancer research. . . . Talent and funds that could be applied to problems of urban blight, disarmament, pollution, poverty, and disease are drained into newer, bigger, better, weapon systems. . . .[5]

In a study of DOD research policy on college campuses, a task force of the Defense Science Board in 1968, highlighted five reasons why interactions between DOD and academia were so controversial.

> (1) *"Locked-Room" Classified Research:* There is an increasingly held view on numerous campuses and a traditional view in some that the sponsorship of classified work (on campus) conflicts with the basic concept of a university as an open institution.
>
> (2) *Support of Classified Work at Federal Contract Research Centers (FCRC) and Other University Affiliated Institutions:* The sponsorship of classified research at FCRCs and other organizations associated with universities, but not on the campus or as part of the academic program. Those opposed to DOD academic research believed universities should not be associated with Pentagon sponsored research, on or off campus.
>
> (3) *The Reserve Officer Training Corps (ROTC) and the University:* Items of concern here were whether the ROTC is an appropriate activity for the university and whether normal academic credit should be given for university courses.
>
> (4) *Recruitment by the Military on Campus:* The universities have been divided on the issue of the freedom of military recruiters and industrial organizations to use the universities facilities for recruiting.
>
> (5) *The DOD's Sponsorship of Unclassified Work:* On some campuses, the question has been raised whether such sponsorship is consistent with the true function and purpose of the university.[6]

The task force also recognized that woven within all of these concerns was the highly volatile issues of the draft and Vietnam war. Indeed, the DSB panel noted that DOD-university relations were unlikely to improve as long as the Vietnam war continued.[7]

The continued conflict in Vietnam, the organized anti-war movement, and DOD's presence on college campuses contributed to widespread activism, unrest and violence on the Nation's campuses. In the 1967 academic year, the FBI estimated that campus unrest had resulted in over $9.5 million worth of damages at colleges and universities.

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[5] Messing, Aubrey F. The University Campus: Why Military-Sponsored Research? Military Review, Dec. 1972: 56.

[6] Report of the Panel on Research Policy 1968 Summer Study Defense Science Board. National Academy of Sciences, June 23–July 5, 1968. p. 21, 22.

[7] Ibid., p. 23.

The protest against DOD supported research forced many universities to change their policy regarding the conduct of both classified and unclassified and research on college campuses. Universities such as New York State University at Stony Brook, Princeton, Massachusetts Institute of Technology (MIT), and Stanford initiated various actions aimed at restricting or banning the support of DOD research on their campuses. In May 1970, the Faculty Senate at Stony Brook University, passed a resolution," that it be SUNY/SB policy not to seek research grants and contracts from the Department of Defense." [8]

Also, in May of 1970, faculty and students and Princeton University passed two resolutions urging Congress "to seek methods of transfer funds for basic research from the Department of Defense to civilian agencies as soon as possible" and a second resolution stating "the department (chemistry) will henceforth discourage all faculty members from accepting any new grants from DOD or any of its subagencies." Faculty who already have DOD funds "are requested to seek other sources of support as soon as possible." [9]

Further, in 1970 both the MIT and Stanford University announced they were dropping their association with their DOD supported Federally Funded Research and Development Centers (FFRDCs) MIT Draper Laboratory and the Stanford Research Institute, that were conducting classified research. However, MIT decided to maintain its other DOD-supported FFRDC Lincoln Laboratory in Lexington, Mass.

Federally Funded Research and Development Centers (FFRDCs (formerly Federal Contract Research Centers (FCRCs)) are funded primarily by a single agency, in this case the Department of Defense. They vary considerably both in size and in their relationship to the sponsoring agency and their affiliated university. The FFRDCs receive a core of stable funding from year to year and do not compete for mission-oriented contracts.

The first FFRDC was the Applied Physics Laboratory at Johns Hopkins University (APL/JHU) which was organized at the request of the wartime Office of Scientific Research and Development (OSRD) in 1942. Its purpose was to give direction and technological support to contractors from universities and industry being organized by OSRD to assist, in the defense of U.S. Naval Forces, utilizing advances in the newly developing area of radio proximity.[10]

Many of DOD's FFRDCs were established near various universities to take advantage of their existing technological expertise and their research and technological objectivity that the military felt it needed. By 1963, there were 39 DOD-sponsored FFRDCs (see table

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[8] Campus Unrest Affects Chemical Education. Chemical and Engineering News. Sept. 7, 1970: 38.

[9] Ibid., p. 39. Parenthesis added.

[10] Report to the Special Study Group on Federal Contract Research Centers (FCRCs) Aug. 30, 1971. p. 5.

5.3).[11] As charts 5-1 and 5-2 indicate, the FFRDCs perform primarily development and applied research but very little basic research.

TABLE 5.3.—FEDERAL CONTRACT RESEARCH CENTERS REPORTED TO THE SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS, HOUSE OF REPRESENTATIVES, MAY 1963

Secretary of Defense:

- Weapons Systems Evaluation Group (Institute for Defense Analyses).
- Support for ARPA (Institute for Defense Analyses).
- Logistics Management Institute.
- Hudson Institute.

Department of the Army:

- Rocket and Propellant Laboratory (Rohm & Hass, Inc.).
- Thiokol Project (Thiokol Chemical Corporation).
- Army Mathematics Center (University of Wisconsin).
- Electronics Research Laboratory (Stanford University).
- Human Resources Research Office (George Washington University).
- Special Operations Research Office (American University).
- Prevention of Deterioration Center (National Academy of Sciences).
- Research Analysis Corporation.

Department of the Navy:

- Allegany Ballistics Laboratory (Hercules Powder Company).
- Thiokol Project (Thiokol Chemical Corporation).
- Ordnance Aerophysics Laboratory (Convair Division, General Dynamics Corporation).
- Electronic Defense Laboratories (Sylvania Electric Products, Inc.).
- Applied Physics Laboratory (Johns Hopkins University).
- Applied Physics Laboratory (University of Washington).
- Hudson Laboratories (Columbia University).
- Naval Biological Laboratory (University of California).
- Ordnance Research Laboratory (Pennsylvania State University).
- Laboratory of Insulation Research (Massachusetts Institute of Technology).
- Arctic Research Laboratory (University of Alaska).
- Electronics Research Laboratory (Stanford University).
- Human Resources Research Office (George Washington University).
- Research Laboratory of Electronics (Massachusetts Institute of Technology).
- Columbia Radiation Laboratory (Columbia University).
- Control System Laboratory (University of California).
- Center of Analysis (Franklin Institute).

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[11] Report of Special Study Group on Federal Contract Research Centers (FCRCs). Office of the Director of Defense Research and Engineering, Washington. Aug. 30, 1971. p. 27.

Department of the Air Force:

- Aircraft Nuclear Test Facility (Convair Division, General Dynamics Corporation).
- Space Technology Laboratory (Thompson Ramo Wooldridge, Inc.).
- Lincoln Laboratories (Massachusetts Institute of Technology).
- Physical Research Laboratory (Boston University).
- Aerospace Corporation.
- ANSER (Analytic Services, Inc.).
- Defense Metals Information Center.
- Mitre Corporation.
- Rand Corporation.

However, in 1964, Harold Brown, Director of Defense Research and Engineering, testified before the Subcommittee on Appropriations of the House, that DOD had studies the list of FFRDCs it gave to the subcommittee in 1963 and felt it was appropriate to reduce the number of centers from 39 down to 21 (see table 5.4).[12] DOD dropped many of its centers because they felt that they had completed their original missions and were no longer needed to assist DOD in achieving its changing mission. Further, different Members of Congress felt that the FFRDCs had too much independence, lacked long-range thinking, were too bureaucratic and performed research of questionable quality and relevance to their supporting agency's mission.[13]

The FFRDCs were a source of controversy on the campuses in the late 1960s because of the nature of the research they conducted. Since most of their research dealt with applied weapons development, it was highly classified. Further, most of the centers were responsible primarily to their government sponsors and usually were independent of university administration. Consequently, many of the faculty and students felt that the centers' work was not primarily related to the main functions and ideals of administering a university and they wished to morally disassociate their institutions with the Department of Defense. As a result, in the late 1960s and early 1970s, some universities began the process of divesting themselves of their DOD-sponsored FFRDCs.

In 1969, a year before MIT and Stanford dropped their FFRDC, there were 18 such laboratories associated with several various universities. Today, DOD only supports two university associated FFRDCs, MIT's Lincoln Laboratory and the newly created (December 1984) Engineering Software Institute at Carnegie Mellon University.[14]

Besides ending their association with FFRDCs and attempting to limit DOD research contracts on college campuses, many universities decided to drop their ROTC programs and limit DOD recruiting on campus. In 1972, the Secretary of the Navy John H. Chaffe, with the support of F. Edward Herbert, Chairman of the House Armed Service Committee, attempted to prevent Naval graduate students from attending universities that had dropped their ROTC programs. The attempted blacklisting of such universities as Boston College, Harvard, Stanford, and Columbia, raised serious congressional concern. Eventually, Members of Congress and the DOD convinced Secretary Chaffe and Congressman Herbert to drop their efforts in this area.[15]

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[12] Ibid., p. 29.

[13] Ibid., p. 9.

[14] For further information on FFRDCs, see: Nelkin, Dorothy. The University and Military Research, Moral Politics at MIT. Cornell University Press 1972, or Report of the Special Study Group on Federal Contract Research Centers, Aug. 30, 1971 (NTIC AD-A007265).

As tensions between DOD and the universities deepened, Congress initiated investigations of the appropriateness of certain DOD sponsored research on college campuses. After much debate Congress passed what became known as the Mansfield Amendment. Attached as a rider to the Military Authorization Act of Fiscal Year 1970 (P.L. 91-121, section 203), the amendment stated:

> None of the funds authorized to be appropriated by this Act may be used to carry out any research project or study unless such a project or study has direct or apparent relationship to a specific military function or operation.

TABLE 5.4.—FEDERAL CONTRACT RESEARCH CENTERS REPORTED TO THE SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS, HOUSE OF REPRESENTATIVES, 1964

Department of the Army:

- Mathematics Research Center (University of Wisconsin).
- Human Resources Office (George Washington University).
- Special Operations Research Office (American University).
- Prevention of Deterioration Center (National Academy of Sciences).
- Research Analysis Corporation.

Department of the Navy:

- Applied Physics Laboratory (Johns Hopkins University).
- Applied Physics Laboratory (University of Washington).
- Center for Naval Analyses (Franklin Institute).
- Hudson Laboratory (Columbia University).
- Ordnance Research Laboratory (Pennsylvania State University).

Department of the Air Force:

- Space Technology Laboratory.
- Aerospace Corporation.
- Lincoln Laboratories (Massachusetts Institute of Technology).
- Mitre Corporation.
- Rand Corporation.
- Anser Corporation.
- Electromagnetic Compatibility Analysis Center.
- International Telephone & Telephone Communications Systems.

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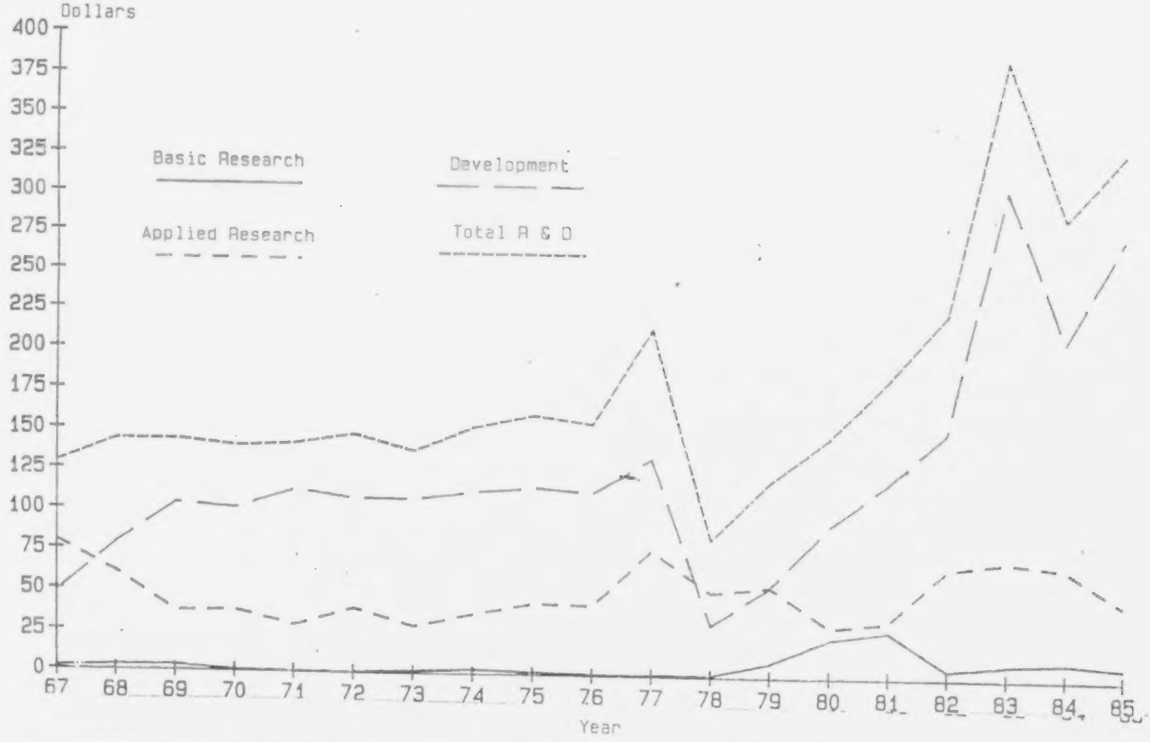
[15] See the Congressional Record. The Chairman of the House Armed Services Committee continues to Intimindate Universities—Honorable Robert F. Drinan. Extension of Remarks Mar. 13, 1972, p. E8190. Also, Congressional Record, Academic Blacklisting and the Defense Dept., Feb. 21, 1972. House. P. H. 4755-4759.

Defense Agencies:

- Institute for Defense Analyses.
- Rand Corporation.
- Hudson Institute.

FIGURE 5.1

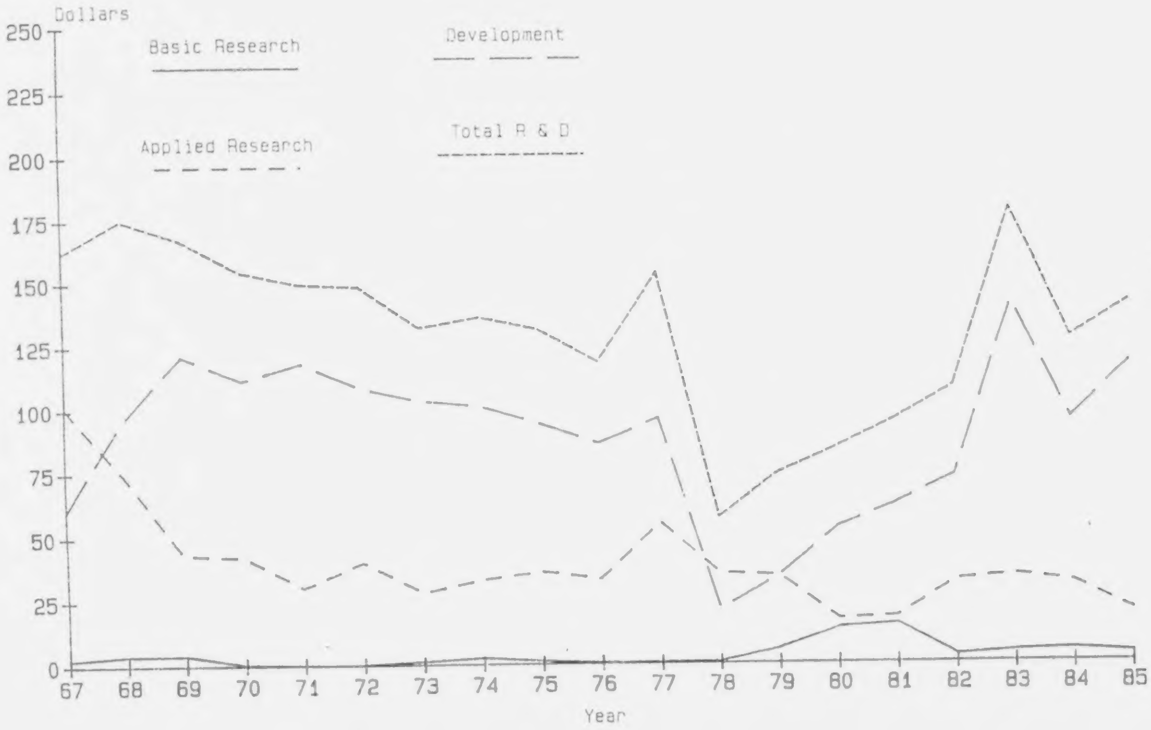
DoD Obligations for Research at FFRDCs Administered by
Colleges and Universities by Character of Work
(millions of current $)



SOURCE: Tables 5.1 and 5.2 were developed from data contained in Federal Funds for Research and Development Detailed Historical Tables: 1955-1986. National Science Foundation.

FIGURE 5.2

DoD Obligations for Research at FFRDCs Administered by Colleges and Universities by Character of Work
(millions of constant 1972 $)



The following year, the language of section 203 was modified in the Military Authorization Act for Fiscal Year 1971 (P.L. 91-441) and became section 204 which provided that:

> None of the funds authorized to be appropriated to the Department of Defense by this or any other act may be used to finance any research project or study unless such project or study has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation.

The modification allows the Secretary of Defense to determine the relevance of the proposed research to the mission of DOD or the sponsoring service branch.

This amendment, which was made applicable to the fiscal year 1971 DOD appropriation is still in effect but of little consequence today. Although the more restrictive Mansfield amendment was only in effect for one year, much of the impact of the two amendments was attributed to this more restrictive version. A small number of DOD-supported research projects were terminated immediately following the enactment of the original amendment. However, according to National Science Board Chairman, Phillip Handler, writing in 1970, the amendment has had a broader impact than originally intended.[16]

> It has been my view, since the passage of section 203 of that authorization, that the philosophy which it espouses has begun to rub off on other agencies which have not themselves been legally affected. Other mission-oriented agencies are obviously regarding their programs as if they had been subjected to the same restriction as the Department of Defense, particularly as they ponder how to reduce their commitments for lack of funds. An illustration is the National Institutes of Health which, in reexamining its programs, has not asked what is the highest quality of science which comes before it for support, but has quite deliberately narrowed down its own view of what areas of science are appropriate. . . .
>
> I have heard similar conversations from representatives of several other agencies. We cannot yet know the total impact of such actions on the Foundation, but the committee should realize that all those scientists whose work is thus affected will be turning to the Foundation for support—and the DOD is only part of the problem.

Despite these actions taken by the universities and Congress, representatives from DOD pointed out that the number of faculty proposals to conduct research for DOD continued to climb. DOD also noted that out of the approximate 5,000 university contracts they supported in 1969, only 200, less than four percent, were classified. The classified contracts were concentrated in 10 to 15 universities. According to DOD sources, out of a $250 million 1969 R&D budget at colleges and universities, only $20 million was spent on classified research.[17]

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[16] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. 1971 National Science Foundation Authorization. Hearings, 91st Cong., 2d Sess. Washington, U.S. Govt. Print. Off., 1970. p. 16-17.

For a further analysis of the Mansfield Amendment, see U.S. Library of Congress. Congressional Research Service. Validity of P.L. 91-441, Sec. 204, the Modified Mansfield Amendment, by David R. Siddall, Mar. 16, 1978. 3 p.

Many university officials contended that protests against DOD had very little effect on campus defense research projects. For example, universities such as Penn State, Johns Hopkins, the University of California, and the University of Rochester decided to maintain their DOD-supported federally funded research and development centers. Other colleges such as the University of Kansas, the University of Illinois (where at the Governors order National Guard troops quelled rioting and destruction of property for a period of time), University of Arizona, Ohio University and Washington University indicated that student demonstrations had "no effect whatsoever" on defense related research.[18]

Finally, many of the proposed resolutions suggesting limiting or banning DOD research on the campuses of schools such as Princeton and Stony Brook were never adopted by university administrators. The primary impact of student protests was the elimination of classified research being conducted on campus.

## D. The Decline of Funding Support

Partly as a result of DOD budget restraints due to Vietnam, increased opposition by the academic community to DOD university sponsored research, increasing concern over societal problems, and the Mansfield amendment, DOD funding for research and development at the nation's universities dropped dramatically between 1965 and 1975. Table 5.5 shows that R&D funding dropped from $291 million in 1965, in current dollars, to $203 million in 1975, a 31 percent decline. In constant 1972 dollars, the funding decline represented a 57 percent loss in purchasing power. DOD support for basic research at universities, in constant dollars, was cut in half. (See table 5.6.) Figures 5.3 and 5.4 show R&D funding to universities from 1966 through 1986.

TABLE 5.5.—DOD SUPPORT FOR RESEARCH AND DEVELOPMENT AT COLLEGES AND UNIVERSITIES IN CURRENT DOLLARS BY CHARACTER OF WORK

[Millions of current dollars]

| Year | Basic research | Applied research | Development | Total |
|---|---|---|---|---|
| 1965 | $132 | $130 | $29 | $291 |
| 1966 | 132 | 130 | 33 | 295 |
| 1967 | 149 | 98 | 33 | 280 |
| 1968 | 132 | 75 | 37 | 244 |
| 1969 | 151 | 71 | 41 | 263 |
| 1970 | 127 | 45 | 44 | 216 |
| 1971 | 130 | 54 | 27 | 211 |
| 1972 | 130 | 46 | 40 | 216 |
| 1973 | 115 | 46 | 43 | 204 |
| 1974 | 106 | 60 | 30 | 196 |
| 1975 | 106 | 59 | 38 | 203 |

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[17] Defense Has Not Changed Its Thinking on Its Relationship with University Research. Government Executive, July 1969: 57.

[18] Protests Have Little Effect on Campus Defense Projects. Baltimore Sun. Sept. 9, 1970: 24.

## TABLE 5.5.—DOD SUPPORT FOR RESEARCH AND DEVELOPMENT AT COLLEGES AND UNIVERSITIES IN CURRENT DOLLARS BY CHARACTER OF WORK—Continued

[Millions of current dollars]

| Year | Basic research | Applied research | Development | Total |
|---|---|---|---|---|
| 1976 | 112 | 80 | 49 | 241 |
| 1977 | 142 | 79 | 52 | 273 |
| 1978 | 168 | 75 | 140 | 383 |
| 1979 | 179 | 92 | 166 | 437 |
| 1980 | 208 | 104 | 183 | 495 |
| 1981 | 244 | 119 | 210 | 573 |
| 1982 | 305 | 107 | 251 | 663 |
| 1983 | 360 | 112 | 252 | 724 |
| 1984 | 405 | 133 | 292 | 830 |
| 1985 estimate | 453 | 191 | 351 | 995 |
| 1986 estimate | 470 | 223 | 372 | 1,065 |

## TABLE 5.6.—DOD SUPPORT FOR RESEARCH AND DEVELOPMENT AT COLLEGES AND UNIVERSITIES IN CONSTANT 1972 DOLLARS BY CHARACTER OF WORK

[Millions of constant 1972 dollars]

| Year | Basic research | Applied research | Development | Total |
|---|---|---|---|---|
| 1965 | $176 | $173 | $38 | $387 |
| 1966 | 171 | 169 | 43 | 383 |
| 1967 | 188 | 123 | 42 | 353 |
| 1968 | 160 | 91 | 45 | 296 |
| 1969 | 183 | 86 | 50 | 319 |
| 1970 | 140 | 49 | 48 | 237 |
| 1971 | 136 | 56 | 28 | 220 |
| 1972 | 130 | 46 | 40 | 216 |
| 1973 | 110 | 44 | 41 | 195 |
| 1974 | 95 | 54 | 27 | 176 |
| 1975 | 86 | 48 | 31 | 165 |
| 1976 | 85 | 61 | 37 | 183 |
| 1977 | 101 | 56 | 37 | 194 |
| 1978 | 112 | 50 | 93 | 255 |
| 1979 | 109 | 56 | 102 | 267 |
| 1980 | 117 | 59 | 103 | 279 |
| 1981 | 125 | 61 | 108 | 294 |
| 1982 | 146 | 51 | 120 | 317 |
| 1983 | 165 | 51 | 116 | 332 |
| 1984 | 179 | 59 | 129 | 367 |
| 1985 estimate | 193 | 82 | 150 | 425 |
| 1986 estimate | 193 | 92 | 153 | 438 |

These budget cuts affected all fields of science. Between 1971 and 1975, the DOD support of university physics departments dropped from 32 to 19 percent of total Federal funding to universities while engineering support declined from 46 percent to 28 percent.[19] A survey of 187 physics and astronomy departments, conducted by the American Institute of Physics in 1969, indicated that 21 percent of those surveyed had lost all their DOD research support. These cuts had affected the work of some 680 professional staff members.[20]

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[19] Dickson, David. The New Politics of Science. Pantheon Books, New York, 1984. p. 123.

[20] Report of the Panel of Research, op. cit., July 1968. p. 11.

Further, in July of 1970, Congress ended DOD's support of Project Themis. Project Themis began in 1966, in response to President Johnson's letter of September 1965 asking Federal R&D agencies to further enhance the Nation's university competence in science and engineering. Only those universities that had received less than $3 million the previous year from DOD, were eligible to compete for 3 year block grants. The primary criteria for selection included, how the project might contribute to the long term goals of the institution, institutional plans for developing "research centers for exellence," rather than proven expertise and the overall research needs of the military.

Although DOD obligated a total of $95.5 million for Project Themis, it never reached its planned $45 million-a-year funding level. In 1969, NSF pointed out that half of the $27 million cut in DOD university research was in Project Themis. NSF stated that "part of this decrease resulted from application of Section 203 of the Military Procurement Authorization Act of 1970 . . . " (the Mansfield Amendment).[21]

### E. DOD BACK ON CAMPUS

Despite the continued estrangement between the university community and the military, the universities still had strong support within the Pentagon. John Foster, director of Pentagon research from 1965 to 1973, remained a strong advocate for DOD interaction with basic research at colleges and universities. Foster argued that:

> National security requires nothing less than the best research talent offered, . . . and that the Federal Government had the responsibility to seek out that talent wherever it could be found . . . including the college campuses.[22]

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[21] Federal Funds for Research, Development and Other Scientific Activities. Fiscal Years 1969, 1970, and 1971 NSF 70-38, v. XIX, p. 10.

Also see University Funding Mechanisms in Support of University Research. Report to the Chairman. U.S. Congress. Committee on Science and Technology. U.S. General Accounting Office. Feb. 1986. p. 144.

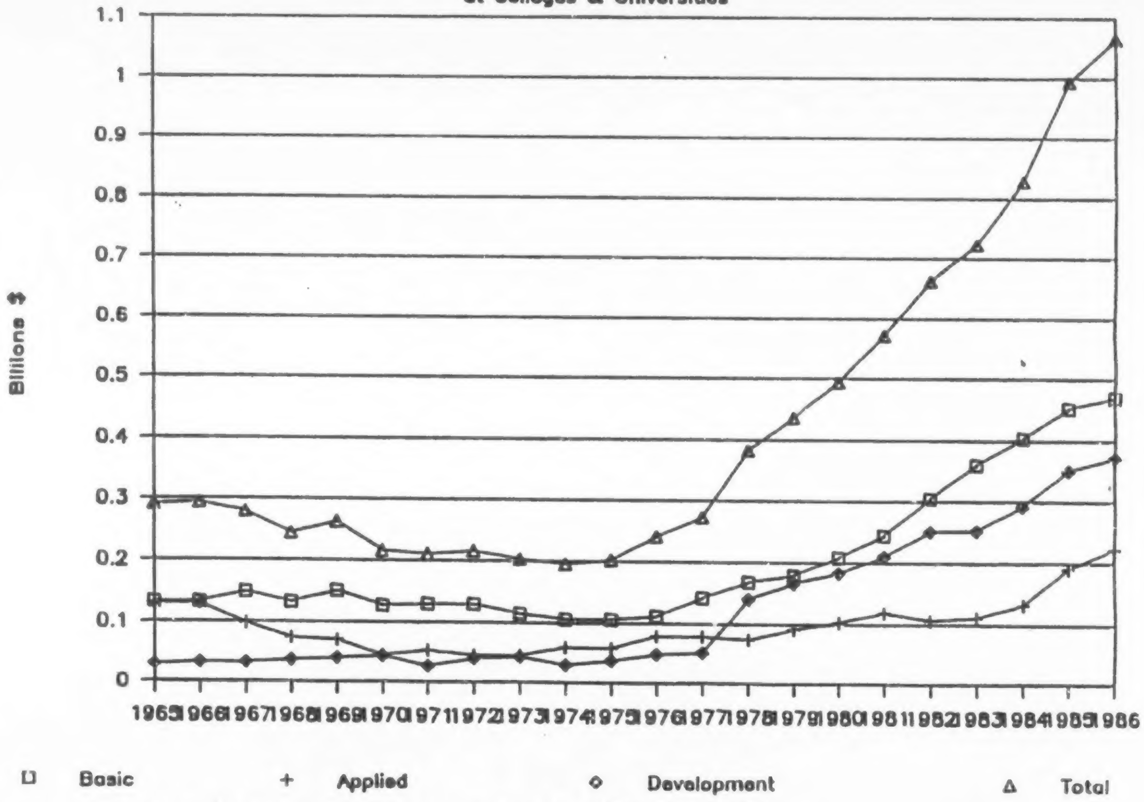
[22] Dickson, op. cit., p. 124.

V.23

FIGURE 5.3

DOD Support of R & D

at Colleges & Universities



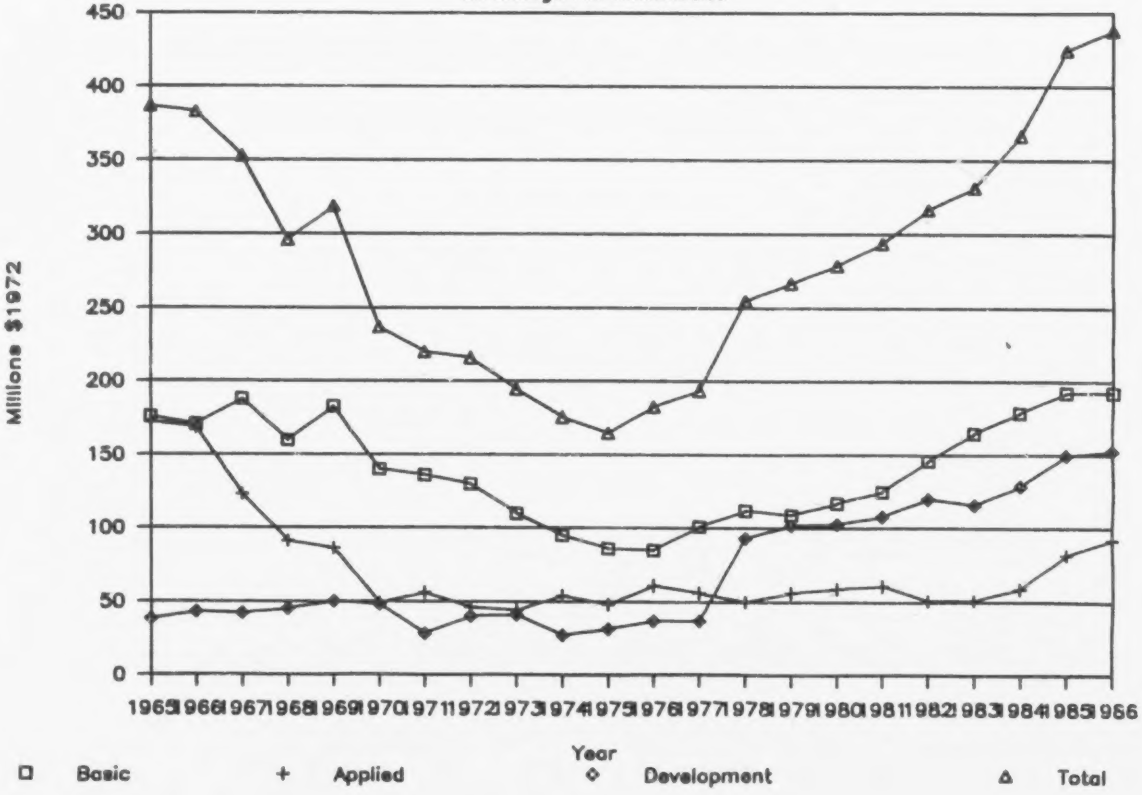
Figures 5.3 and 5.4 were developed from data contained in tables 5.5 and 5.6.

V.24

FIGURE 5.4

DOD Support of R & D

at Colleges & Universities



Further, the election of Jimmy Carter as President and his subsequent appointment of Harold Brown as Secretary of Defense initiated a turning point for DOD support of basic research. As the new Secratary of Defense, Brown made it clear that the accelerated development and modernization of military technologies by the Soviet Union required a strong U.S. response. Consequently, both Secretary Brown and William Perry, Under Secretary of Defense for Research and Engineering indicated that to adequately meet the Soviet threat, the Pentagon must increase its support of basic research in such areas as microelectronics, computers, material science, and lasers. In August of 1980, Secretary Brown announced a commitment to increase DOD funding for basic research by 10 percent a year in real dollars for the next decade.

Justification for increased DOD funding for basic research came from a 1978 "Report of the Working Group on Basic Research in the Department of Defense." Established by the Office of Science and Technology Policy, the working group, chaired by J.K. Galt of Sandia Laboratories, was established to review the policies and practices of the basic research program in the Department of Defense. Known as the Galt Report, the panel issued a number of strong recommendations calling for an increase of Pentagon support for basic research.[23]

The Galt report indicated that basic research is essential for the modernization of our military forces. The report noted that in 1976 DOD funding for basic research was about half of the 1966 level. As table 5.6 shows in constant 1972 dolars, the same could be said for DOD funding of basic research at colleges and universities. Although the panel did not recommend a specific amount that basic research funding should be increased they did state that such an initiative should "result in healthy and orderly growth in the research community supporting the defense establishment."[24] However, the report went on to suggest that increased funding for basic research in the next ten years should be about equal to the decline of DOD funding for the previous ten years.

The panel members also recognized that strong DOD support for basic research at colleges and universities provides the Pentagon with a diverse group of scientists and engineers who understand the DOD research environment and its particular research needs. Also, the DOD basic research program provides the military with direct access to available scientific and engineering talent that could be employed to help solve future scientific and technological challenges. Consequently, the panel endorsed DOD's decision to make a concerted effort to renew and enhance working relationships with the Nation's colleges and universities.

The panel members also addressed the controversial issue of relevance. Emerging from the Mansfield amendment, the Galt report recognized that the Pentagon should not be supporting an uncontrollable basic research program. Rather, priorities that focus on the anticipated research needs of DOD should be established, to help insure greater relevance. Further, the study noted that "fields of potential use" for the military do not remain fixed over time. Research which was once considered relevant to the needs and mission of DOD could eventually be viewed as totally unrelated to DOD needs.[25]

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[23] Report of the Working Group on Basic Research in the Department of Defense. Executive Office of the President Office of Science and Technology Policy. June 22, 1978. p. 3.

[24] Ibid., p. 7.

The panel concluded its remarks on relevance by stating:

> In deciding which proposed projects to support, the research manager in government should not use narrowly-identified relevance as a filter through which every project should pass, but rather should apply a broad concept to wide areas of science.[26]

Finally, the Galt report recommended the establishment of a senior position within the Office of the Secretary of Defense, in order to improve the management and oversight of DOD basic research. At that time, according to the panel, the Deputy Secretary of Defense for Research and Engineering was the official charged with overseeing DOD's basic research programs. However, the panel felt that DOD's basic research programs are so broad, covering a diverse range of scientific areas that it merits the full-time attention of a senior Pentagon official. This resulted in the establishment of the office of Research and Laboratory Management, which was given authority over DOD's basic research programs, as well as DARPA.

Utilizing the findings of the Galt report, Secretary Brown and William Perry persuaded the Office of Management and Budget to provide steady increases for DOD's basic research programs. This resulted in DOD increasing its support for basic research 86 percent, from $112 million to $208 million, between 1976–1980. (See table 5.5.)

The election of Ronald Reagan as President further accelerated basic research funding with the Department of Defense. Like his immediate predecessor, newly appointed Secretary of Defense Casper Weinberger issued a memorandum in the summer of 1981 calling the current national base of support for basic research inadequate to meet future DOD needs.[27] Consequently, budget proposals submitted to Congress for FY 1982 implied that universities could expect,a 16.5 percent increase in military R&D funds.

In fact, between 1981 and 1986, NSF estimates that DOD's overall support of basic research will have increased 60 percent in current dollars and 34 percent in constant dollars. While as indicated by tables 5.5 and 5.6, during the same time period DOD support for basic research at the Nation's universities increased 93 percent in current dollars and 54 percent in constant 1972 dollars. Although DOD's figures for support of basic research funding to colleges from 1981 to 1986 are not exactly the same as NSF's, (see table 5.7) they still indicate an 84 percent increase in current dollars and 46 percent increase in constant 1986 dollars. Between FY 1976 and FY 1986, DOD's overall funding of research and development to the Nation's universities increased from $241 million to $1,065 million, a 342 percent increase. In comparison during this period, total Federal R&D funding to colleges and universities increased only 150 percent. In constant dollars overall DOD R&D support to colleges and universities increased 139 percent, with basic research and development funding increasing 127 and 313 percent respectively.

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[25] Ibid., p. 10.
[26] Ibid., p. 11.
[27] Dickerson, p. 128.

In FY 1976, development funding represented only 20 percent of DOD total R&D expenditures to the Nation's colleges and universities. However, by FY 1986 development funding had reached 35 percent of total DOD support. (See figures 5.5 and 5.6.) In fact, as indicated above, between FY 1976 and FY 1986 development funding grew at three times the rate of basic research funding. As table 5.5 and 5.6 indicate, in 1978 DOD funding for development surpassed applied research funding for the first time. In FY 1986, applied research represented approximately 21 percent of total DOD funding to universities, dropping from 33 percent in FY 1976; an almost exact reversal of development funding trends.

Faced with potential declining research support from civilian agencies, many university leaders strongly endorsed the Pentagon's new initiatives. Testifying before the House Armed Services Committee in April of 1981, representatives from the American Council on Education, the National Association of State Universities and Land Grant Colleges, and the Association of American Universities strongly endorsed DOD's efforts to improve relations with the Nation's universities and help to repair the universities "research base for defense preparedness." [28] During the hearings, these same representatives also encouraged the Pentagon to increase its funding of research to colleges and universities.

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[28] U.S. Congress. House. Committee on Armed Services. Subcommittee on Research and Development. Capability of the Academic Community to Respond to R&D Needs. Hearings, 97th Cong., 2nd Sess., Apr. 3, 1981.

TABLE 5.7

DEPARTMENT OF DEFENSE FUNDING FOR UNIVERSITY BASIC (6.1) RESEARCH, FISCAL YEARS 1974-86
(In millions of dollars)

| | FY 74 | | FY 75 | | FY 76 | | FY 77 | | FY 78 | | FY 79 | | FY 80 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Service | Current | Real | Current | Real | Current | Real | Current | Real | Current | Real | Current | Real | Current | Real |
| ARMY | 13.7 | 27.9 | 13.4 | 25.0 | 19.0 | 33.7 | 23.7 | 39.6 | 28.1 | 43.8 | 32.0 | 45.9 | 38.1 | 50.1 |
| AIR FORCE | 23.2 | 47.3 | 22.9 | 42.6 | 28.2 | 50.0 | 41.0 | 68.6 | 49.5 | 77.1 | 46.4 | 56.6 | 55.3 | 72.7 |
| NAVY | 45.5 | 92.7 | 47.0 | 89.2 | 64.2 | 113.8 | 62.7 | 104.8 | 70.8 | 110.3 | 86.4 | 124.0 | 100.2 | 131.7 |
| DARPA | 21.9 | 44.6 | 19.4 | 36.1 | 19.1 | 33.9 | 18.7 | 31.3 | 17.9 | 27.9 | 21.0 | 30.1 | 19.8 | 26.0 |
| TOTAL | 104.3 | 212.4 | 103.6 | 192.9 | 130.5 | 231.4 | 146.1 | 244.3 | 166.3 | 259.0 | 185.8 | 266.6 | 213.4 | 280.4 |

| | FY 81 | | FY 82 | | FY 83 | | FY 84 | | FY 85* | | FY 86* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Service | Current | Real | Current | Real | Current | Real | Current | Real | Current | Real** | Current | Real** |
| ARMY | 46.5 | 55.9 | 56.1 | 63.5 | 71.4 | 77.7 | 80.6 | 84.6 | 83.8 | 83.8 | 87.9 | 83.8 |
| AIR FORCE | 63.4 | 76.2 | 71.5 | 81.0 | 90.3 | 98.3 | 112.1 | 117.6 | 119.1 | 119.1 | 135.0 | 128.7 |
| NAVY | 115.0 | 138.2 | 142.3 | 161.2 | 152.2 | 165.6 | 158.1 | 165.9 | 176.1 | 176.1 | 198.8 | 189.5 |
| DARPA | 27.3 | 37.8 | 39.4 | 44.6 | 46.4 | 50.5 | 53.9 | 56.6 | 42.7 | 42.7 | 43.4 | 41.4 |
| TOTAL | 252.2 | 303.1 | 309.3 | 350.3 | 360.3 | 392.1 | 404.7 | 424.7 | 421.7 | 421.7 | 465.1 | 443.4 |

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* Projections

** Forecast for inflation is based on CBO projection

SOURCE: Army Deputy Chief of Staff Research Development and Acquisition, Office of Naval Research, Air Force Office of Scientific Research, Defense Advanced Research Projects Agency, (Constant 1985 Dollars Calculated using GNP Implicit Price Deflator)

Although the subsequent increases represent impressive gains, in constant 1972 dollars DOD support for R&D on the nation's campuses did not surpass FY 1966 levels until FY 1985. Nevertheless, DOD estimates that in FY 1987 it will surpass the National Science Foundation (NSF) as the second largest supporter of research and development on college campuses. The Defense department is the largest supporter of Federal funding for development on college campuses. This rapid growth of development funding has raised some concerns on university campuses because almost all development funds are classified.

An additional new source of substantial DOD research funding to colleges and universities is the Strategic Defense Initiative (SDI). To facilitate further involvement of the Nation's universities in the SDI program, SDI Director General James Abrahamson established and Innovative Science and Technology Office (IST). Directed by physicist James A. Ionson, the IST Office is planning to dispense to colleges and universities up to 5 percent of the $26 billion that the Administration plans to spend for SDI research over the next 5 to 6 years. In FY 1985 and FY 1986, the IST Office estimates they will have funded over $229 million in research grants to various university consortia and individual researchers. In FY 1987, DOD estimates SDIO and IST will fund $264 million worth of research at colleges and universities.[29]

## F. DOD Support of University Research Infrastructure

Except in specific cases, the Pentagon has not undertaken any general responsibility to help universities develop their research infrastructure. University infrastructure consists of laboratory facilities necessary to conduct research at various colleges and universities. It also includes availability of scientific and technical manpower to meet R&D requirements.

Although DOD's research funding has always allowed for the purchase of necessary and reasonable research equipment, DOD, until FY 1983, had not sponsored a program strictly for the purchase of research equipment. DOD has, however, as have other research support agencies, paid the indirect cost allowances for equipment use.

Now, besides approving legislation to increase research funding to colleges and universities, Congress and the Administration have initiated a number of activities to enhance relations between the Pentagon and the Nation's universities. For example, the House of Representatives in its FY 1984 DOD Authorization report instructed the DOD to undertake a survey to assess

> the needs to modernize university laboratories in the physical sciences, earth and ocean sciences, atmospheric sciences, engineering, computer sciences and other fields essential to our long term national security.[30]

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[29] Funding figures provided by DOD, July 1986.

[30] The Dept. of Defense Report on Selected University Laboratory Needs in Support of National Security. Prepared for the Subcommittee on Research and Development of the Committee on Armed Services of the U.S. House of Representatives. Apr. 29, 1985. (Hereafter cited as Laboratory Needs Study.)

Concomitantly, the Senate Armed Services Committee, in a report dated May 31, 1984, requested DOD to conduct an analysis "detailing DOD activities and plans to support the United States infrastructure for science and engineering education and research." [31]

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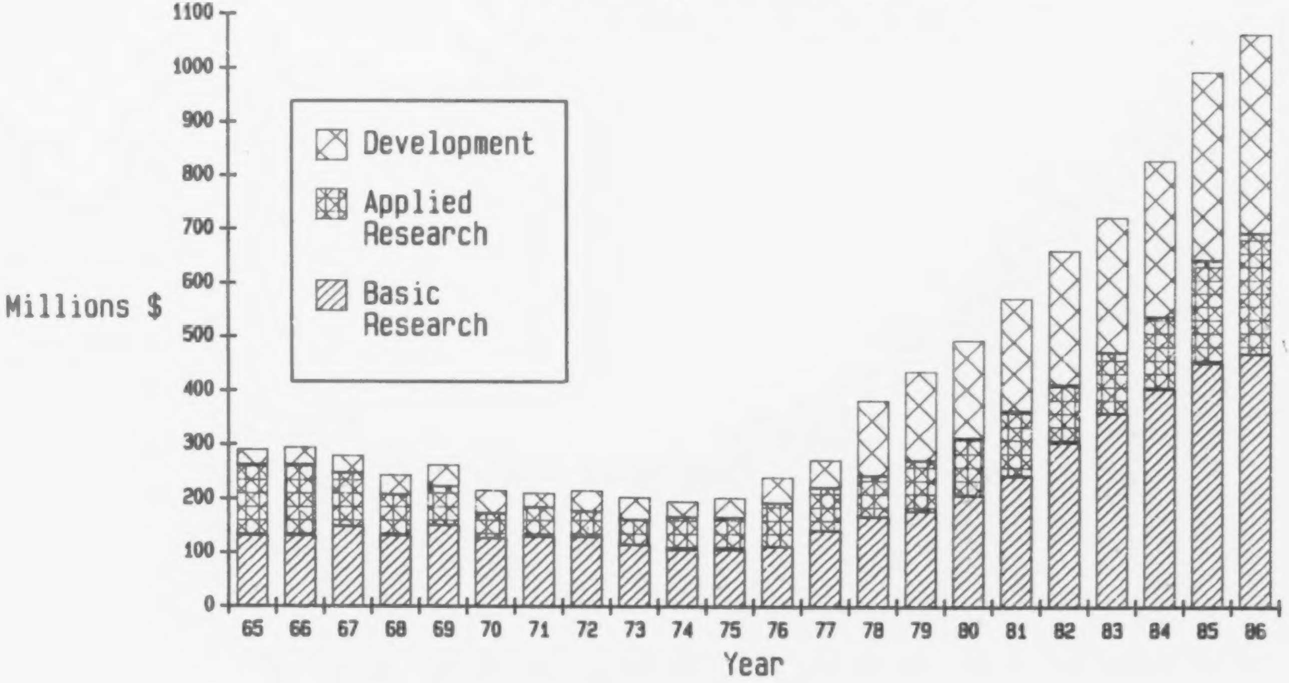
[31] The Department of Defense Report on the Technology Base and Support of University Research. The Committee on Armed Services. U.S. Senate. Mar. 1, 1985. (Hereafter cited as the Technology Base Study.)

v.32

FIGURE 5.5

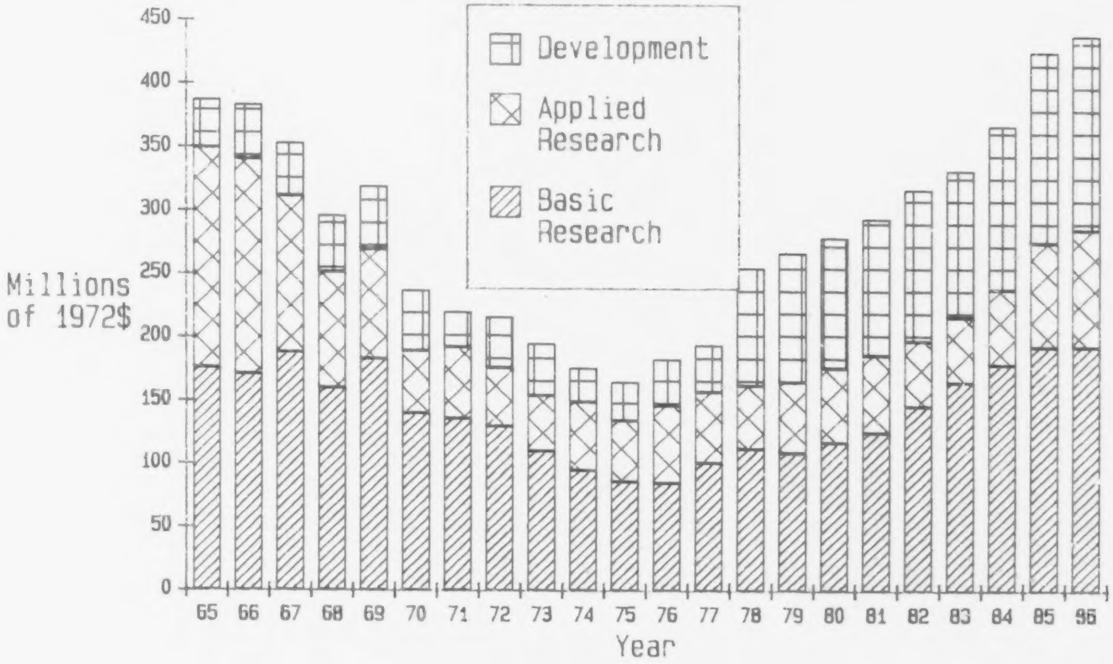
DOD Support for Research & Development
at Colleges & Universities



V.33

FIGURE 5.6

DOD Support of R&D
at Colleges and Universities



However, through its existing contacts with university researchers, the Pentagon became aware of a considerable instrumentation problem before the House and Senate studies were released. Consequently, Congress approved, beginning FY 1983, the University Research Instrumentation Program. URIP will provide, subject to annual appropriations, over a five-year period, $150 million for the purchase of university research equipment costing more than $50,000 per unit. Each of the three services will spend $10 million per year for URIP. In the first year of the program, DOD received 2,500 proposals, for a total of $646 million.

Both House and Senate reports on DOD concluded that the overall university research infrastructure had deteriorated significantly during the decade of the seventies and early eighties. The House Armed Services Committee (HASC) report, which focused on research laboratory needs, primarily instrumentation, in five different subject areas namely chemistry, electronics, engineering, materials and physics, recommended that DOD's University Research Instrumentation Program (URIP) be extended three more years.

The House report concluded that the final two years of the URIP consisting of $60 million in funding, plus an additional three years or $90 million should be enough to meet the $150 million priority 1 instrumentation needs identified by the HAS report. By contrast, during testimony before Congress in 1984, DOD representatives testified that it could cost up to $2 billion (from all sources) to replace obsolete university research instrumentation.[32]

DOD has also encouraged university researchers to include the purchase of needed research equipment in their research proposals. In response, in fiscal year 1984, an additional $45 million, approximately ten percent of Army, Navy, Air Force and DARPA research contract funding at universities, was applied to the purchase of research equipment.[33]

In addition to examining funding and instrumentation needs at colleges and universities, DOD's Senate report also examined future Pentagon manpower needs. The report noted that for the United States to maintain superiority in various science and technology areas, will primarily depend on how successful universities are in providing new scientific and technological talent. A recent National Science Foundation (NSF) study indicated that growing defense spending will increase the share of the Nation's engineers employed in defense related activities, from 12 percent in 1982, to 15 percent by 1987. In 1982, the Pentagon directly employed over 105,000 engineers and scientists (3.6 percent of the national total).[34] Some are concerned that these growing demands for engineers, by DOD, could lead to manpower shortages in computer specialists, aeronautical engineers, and electrical/electronic engineers.

The Senate study reported the number of Ph.D.s in engineering earned by U.S. citizens declined 42 percent between 1968 and 1982.[35] Nearly half of all engineering Ph.D.s are now awarded to foreign nationals. The trend could soon present DOD with serious problems because foreign students and faculty usually cannot obtain security clearances and are not eligible to work on classified research projects.

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[32] Testimony before Congress as summarized in: U.S. Congress. House. Committee on Science and Technology. Summary and Analysis of Hearing on Improving the Research Infrastructure at U.S. Universities and Colleges. Report prepared by Congressional Research Service, Library of Congress. Washington, U.S. Govt. Print. Off., 1984. p. 4. (Committee print).

[33] Information supplied by DOD.

[34] The Technology Base, p. 22.

[35] The Technology Base, p. 23.

## G. DOD Educational Programs

Military training at colleges and universities began in 1819 at Norwich University. In 1862, the Merrill Act provided land and later financial assistance to colleges offering training in agriculture, mechanical arts, and military tactics. The National Defense Act of 1916 established the Army's Reserve Officers Training Corps (ROTC) program. The Navy and the Air Force established their ROTC programs, in 1925 and 1947 respectively.[36]

In its earliest days, the military's ROTC program provided only subsistance allowances for each participant. It was not until 1946, when the Navy's "Holloway Plan" was adopted, that ROTC students (Navy) received scholarship assistance in the way of tuition, books fees, and a monthly subsistence allowance.

In 1964, Congress passed the ROTC Vitalization Act in an attempt to increase the number of commissioned officers. For the first time, the Act authorized all three services to provide scholarship assistance to students. The legislation also established ROTC programs at 2 year institutions, allowing ROTC students to transfer to 4 year institutions. The 1964 Act also established a specific number of scholarships for each service which by 1971 stood at 6,500 for the Army and Air Force and 6,000 for the Navy.[37]

The number of students receiving ROTC scholarships has grown considerably in recent years. Further, from fiscal year 1980 to fiscal year 1985, the total number of authorized scholarships will increase 55 percent, from 19,000 to 29,500. The Navy and Air Force require that 80 percent and 70 percent, respectively, of their scholarship recipients enroll in science and engineering fields of study, while the Army has no such stipulation.

In fiscal year 1985, the three services supported approximately 250 graduate students, with 125 new fellows proposed for the Graduate Fellowship Program in FY 86. To enable DOD to help with academic infrastructure needs, the Administration proposed to spend $25 million in FY 1986 and $50 million in FY 1987 for the University Research Initiative (URI). According to the Administration, the URI will "address some of the concerns expressed by Congress regarding DOD support for the infrastructure of science and technology in the United States," [38] particularly at colleges and universities.

In light of how serious many in the scientific community believe the infrastructure problem is, House and Senate Conferees, on July 29, 1985, in the DOD Authorization Act of 1986, recommended $100 million for the URI. The $100 million funding level was sustained in H.J. Res. 465, continuing resolution for FY86 appropriations, but was reduced to $95 million as a result of the Gramm-Rudman-Hollings (GRH) deficit reduction mechanism. For FY 1987 and FY 1988, DOD has requested $50 and $100 million for the URI program. This is a substantially lower funding level than the director of research and laboratory management had originally requested.

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[36] U.S. Congress. House. Committee on Appropriations. A Report to the Committee on the Reserve Officer Training Corps (ROTC) Scholarship Program. Survey and Investigations Staff. Mar. 1984. p. 3.

[37] Ibid., p. 3.

[38] Colonel Donald I. Carter, USAF, Acting Deputy Under Secretary of Defense for Research and Advanced Technology. Before the Subcommittee on Research and Development of the House Armed Services Committee. Apr. 2, 1985.

DOD's URI program consists of two major program elements. The first element consists of multidisciplinary research centers and programs, designed to enhance interdisciplinary research efforts between universities, industry and DOD laboratories. These research centers will conduct research in a range of disciplines (mathematics, engineering, and the physical, biological and social sciences) important to the Pentagon. The Centers established at different universities, will increase funding for high risk basic research in support of critical defense technologies, as well as continuing support (in place of URIP) of equipment and instrumentation.[39]

The second major program element is the "Programs to Develop Human Resources in Science and Engineering." This program element is designed to increase DOD's support for fellowships, postdoctoral, young investigators, and scientific exchange programs, that promote interaction between scientific and engineering personnel in DOD laboratories and universities.

In January of 1982, a Defense Science Board task Force studying university DOD relations recommended the establishment of a "forum to allow periodic consultations between senior university representatives and DOD officials on the full range of research-related needs and issues that affect the department's ties with universities.[40] Established in December of 1983, the DOD-University forum consists of an almost equal number of DOD and university members and is co-chaired by the Under Secretary of Defense for Research and Advanced Technology and Dr. Donald Kennedy, President of Stanford University. The forum has issued reports dealing with such subjects as scientific secrecy and technology export control, engineering and science education needs and DOD's response to those needs. Most recently, the form's working group on engineering and science education developed a draft report which established the major components of the newly created University Research Initiative.

## H. DOD Support of Research by Field of Science [41]

When DOD was the primary supporter of university based research, the Pentagon's broad scientific requirements justified its support of a wide range of scientific endeavors. Consequently, DOD was able to venture into many of the most exciting frontier fields of research, including elementary physics, computer science, quantitiative behavioral science, molecular biology, satellite technology, radioastronomy, x-ray and y/ray astronomy, cryogenics, and high pressure physics.[42]

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[39] U.S. Dept. of Defense, FY 1986 University Research Initiative Program Overview. Office of the Under Secretary of Defense for Research and Engineering, Dec. 1985. p. 2.

[40] Report of the DOD-University Forum Calendar Year 1984. Office of the Under Secretary of Defense for Research and Engineering. Dec. 1984. p. 1. Also see Report of the Defense Science Board Task Force on University Reponsiveness to National Security Requirements. Office of the Under Secretary of Defense for Research Engineering. Washington, Jan. 1982. p. XI.

[41] In this section research refers to both basic and applied research as reported by NSF. DOD's corresponding classification is 6.1, basic research and 6.2, exploratory development, or what DOD calls the technology base.

For example, the Advanced Research Project Agency, (ARPA) pioneered support in the area of computer software research. ARPA also played a crucial role in the development of computer science as a new discipline in universities. At the suggestion of the Federal Council for Science and Technology, ARPA established the first long-term support for materials science in universities. This program was different from past DOD research activities in that it was interdisciplinary, providing financial support for scientists and research equipment for research groups, rather than for single investigator. APRA's materials research laboratory program also used the procedure of funding research over a period of several years. This helped universities to develop long-range plans for increasing faculty positions, and graduate student enrollment, and for managing facility needs. By the late 1960s, ARPA had initiated research into the field of behavioral sciences, focusing on such areas as improved methodologies for studying social systems.[43]

More recently, universities and colleges have gained from increased DOD research funding on college campuses. In FY 1986, the Pentagon placed half of its basic research work at colleges and universities (see figure 5.7). This is up from a low of 35 percent in 1976 and 40 percent in 1980. As a percentage of total Federal support for R&D at universities, DOD's share of the total has doubled from 8 percent in FY 1975 to an estimated 16 percent in FY 1985 (see table 5.1). The Pentagon's growing influence and support of research is also evident in various scientific fields. Figure 5.8 illustrates the extent to which mathematics and computer sciences have become a larger portion of DOD's research programs.

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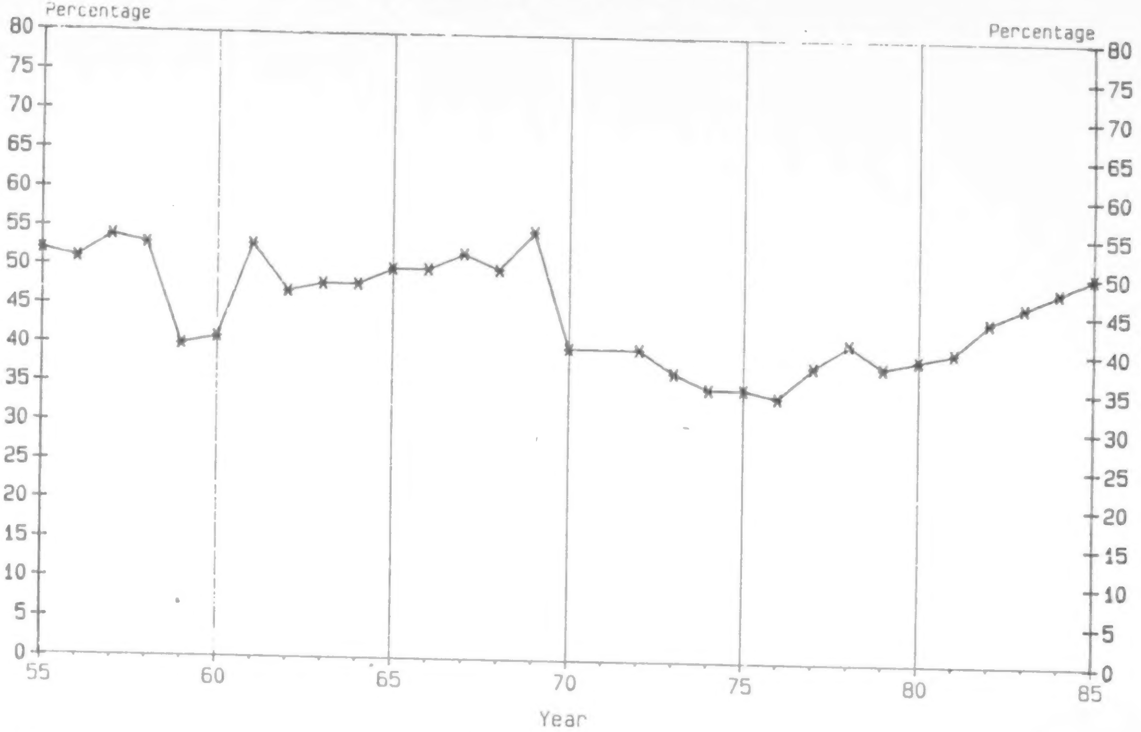
[42] Brooks, Harvey. Impact of the Defense Establishment on Science and Education, Oct. 1970. Hearings on National Science Policy. H. Con. Res. 666, before Committee on Science and Astronautics. Subcommittee on Science, Research and Development, July 7, 1970. Appendix E. p. 944. (Hereafter referred to as the Brook's Article.)

[43] Brooks' Article. p. 944.

FIGURE 5.7

Percentages of Total DoD Support for Basic Research Performed at Colleges and Universities*



*Excluding FFRDCs Administered by Universities , tabled developed from NSF data.

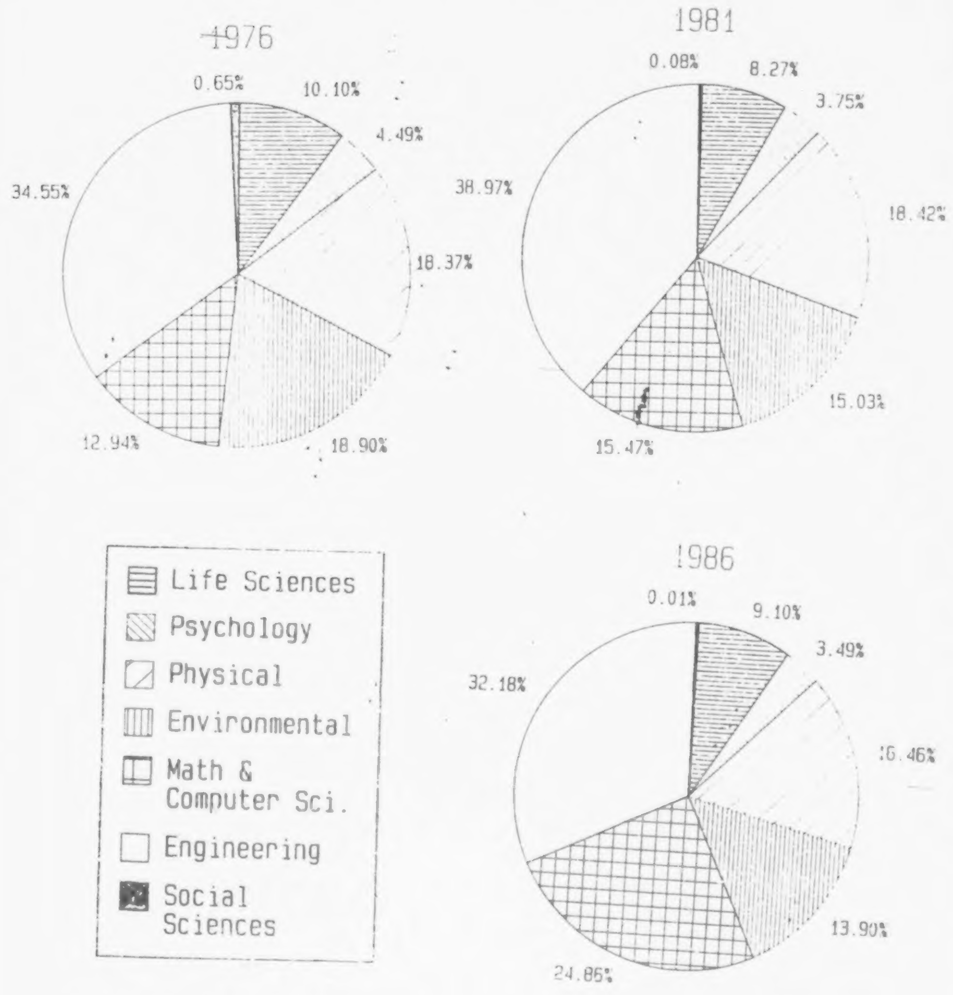
Table 5.8
DOD Support of Research
at Colleges & Universities
by Fields of Science [1]
(millions of current $)

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 (Estimate) | 1986 (Estimate) | Percent Change 1976-1986 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Life Sciences | | | | | | | | | | | | |
| All Agencies | $1,247.2 | $1,399.9 | $1,605.2 | $1,796.0 | $1,984.7 | $2,117.2 | $2,205.0 | $2,460.0 | $2,800.2 | $3,221.4 | $3,055.6 | 145.0% |
| DOD | 17.1 | 19.4 | 19.9 | 21.2 | 28.0 | 30.0 | 41.9 | 41.9 | 55.0 | 53.0 | 62.0 | 262.6% |
| Percent DOD | 1.4% | 1.4% | 1.2% | 1.2% | 1.4% | 1.4% | 1.9% | 1.7% | 2.0% | 1.6% | 2.0% | |
| Psychology | | | | | | | | | | | | |
| All Agencies | 58.4 | 59.2 | 67.7 | 89.8 | 89.4 | 92.7 | 83.5 | 99.0 | 112.8 | 128.9 | 128.0 | 119.2% |
| DOD | 7.6 | 8.8 | 10.8 | 11.3 | 12.5 | 13.6 | 14.3 | 17.6 | 19.7 | 22.3 | 23.8 | 213.2% |
| Percent DOD | 13.0% | 14.9% | 16.0% | 12.6% | 14.0% | 14.7% | 17.1% | 17.8% | 17.5% | 17.3% | 18.6% | |
| Physical Sciences | | | | | | | | | | | | |
| All Agencies | 278.1 | 326.1 | 366.6 | 402.8 | 461.0 | 525.2 | 559.1 | 596.5 | 697.8 | 784.0 | 829.2 | 198.2% |
| DOD | 31.1 | 37.0 | 43.5 | 50.5 | 55.1 | 66.8 | 78.1 | 70.7 | 89.4 | 99.9 | 112.2 | 260.8% |
| Percent DOD | 11.2% | 11.3% | 11.9% | 12.5% | 12.0% | 12.7% | 14.0% | 11.9% | 12.8% | 12.7% | 13.5% | |
| Environmental Sciences | | | | | | | | | | | | |
| All Agencies | 168.6 | 205.2 | 226.5 | 275.5 | 297.0 | 280.3 | 274.7 | 316.9 | 319.5 | 340.7 | 364.4 | 116.1% |
| DOD | 32.0 | 37.6 | 51.0 | 54.6 | 52.8 | 54.5 | 62.9 | 71.4 | 78.0 | 81.6 | 94.7 | 195.9% |
| Percent DOD | 19.0% | 18.3% | 22.5% | 19.8% | 17.8% | 19.4% | 22.9% | 22.5% | 24.4% | 24.0% | 26.0% | |
| Mathematics & Computer Sciences | | | | | | | | | | | | |
| All Agencies | 57.6 | 72.9 | 79.5 | 87.5 | 94.6 | 121.4 | 139.7 | 172.4 | 181.4 | 250.2 | 288.3 | 400.5% |
| DOD | 21.9 | 29.5 | 33.2 | 40.6 | 38.7 | 56.1 | 68.4 | 89.9 | 95.8 | 136.7 | 169.4 | 673.5% |
| Percent DOD | 38.0% | 40.5% | 41.8% | 46.4% | 40.9% | 46.2% | 49.0% | 52.1% | 52.8% | 54.6% | 58.8% | |
| Engineering | | | | | | | | | | | | |
| All Agencies | 172.3 | 220.6 | 240.9 | 269.6 | 323.7 | 365.3 | 361.5 | 408.7 | 474.2 | 521.2 | 566.8 | 229.0% |
| DOD | 58.5 | 87.9 | 82.8 | 91.6 | 124.0 | 141.3 | 146.3 | 169.0 | 189.9 | 194.6 | 219.3 | 274.9% |
| Percent DOD | 34.0% | 39.8% | 34.4% | 34.0% | 38.3% | 38.7% | 40.5% | 41.4% | 40.0% | 37.3% | 38.7% | |
| Social Sciences | | | | | | | | | | | | |
| All Agencies | 118.7 | 136.6 | 146.1 | 138.2 | 137.8 | 136.4 | 113.5 | 125.4 | 111.1 | 121.6 | 114.2 | -3.8% |
| DOD | 1.10 | 0.70 | 1.00 | 1.00 | 0.80 | 0.30 | 0.03 | 0.02 | 0.06 | 0.06 | 0.05 | -95.5% |
| Percent DOD | 0.93% | 0.51% | 0.68% | 0.72% | 0.58% | 0.22% | 0.03% | 0.02% | 0.05% | 0.05% | 0.04% | |

[1] Table developed from data contained in, Federal Funds for Research and Development Federal Obligations for Research to Universities and colleges, by Agency and Detail Field of Science: Fiscal Years 1973-1986. National Science Foundation

FIGURE 5.8

DOD Support of Research at Universities
by Field of Science*



*Basic and applied research.

As table 5.8 illustrates, between FY 1976 and FY 1986 DOD steadily increased its support of research in all fields except the social sciences category. The most dramatic increase occurred in mathematics and computer science, which experienced a six fold increase since FY 1976.

The Pentagon supports only 2 percent of Federal life sciences research at universities. DOD's life sciences program is highly mission oriented. For example, DOD's life sciences program supports research in the prevention and treatment of "military significant" diseases and the care of the combat wounded. More specific areas of life sciences research include food nutrition science; the epidemiology, microbiology, immunology, and pathophysiology of infectious diseases; biotechnology and combat casualty care.[44]

The military share of Federal support to universities for psychology research in 1986 was over 23 percent. DOD ranks second in total funding for psychological research behind the National Institutes of Health. DOD is the largest supporter of research in the area of "social aspects of psychology" (e.g., organizational effectiveness and personnel training) providing almost 54 percent of total Federal funding. Total military research funding for psychology to universities has increased three fold since FY 1976.

DOD's most diverse research activities are in the physical sciences. Research in the physical sciences includes such broad areas as physics, radiation science, astronomy, astrophysics, electronics and chemistry. DOD funding to universities for physical sciences research has increased 260 percent since FY 1976. In the area of ultrasmall electronics, DOD is pushing the frontier of electronics with the goal of generating devices with critical dimensions no larger than a molecule. Research in chemistry focuses on such areas as chemical and biological defense, laser chemistry, chemical processing polymers, and energetic materials for propellants and explosives.

The Department of Defense is the second largest supporter of environmental research on the Nation's campuses, providing 26 percent of all Federal research support. The Pentagon's environmental research program is aimed primarily at meeting the needs of the Navy's ocean sciences program. The Navy's ocean sciences program is a broad-based, multidisciplinary program that includes physical oceanography, ocean acoustics, biological and chemical oceanograph. marine meteorology, marine geology and geophysics, mapping, and environmental protection.[45]

DOD dominates Federal research funding in mathematics and computer science by providing over half of all Federal funding to colleges and universities. The data in table 5.8 indicate that such funding (in current dollars) has increased over 600 percent since FY 1976.

In the area of mathematical research, DOD's funding has increased from $13 million in FY 1979 (the first year NSF reported separate funding for mathematics and computer research) to over

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[44] Most of the information in this section comes for Basic Research Programs, the Department of Defense. Office of the Deputy Secretary of Defense for Research and Engineering (Research and Advanced Technology/Research and Laboratory Management), 1985.

[45] Office of Naval Research Guide to Programs. Office of Naval Research, Mar. 1985. p. 70.

$35 million in FY 1986, a 170 percent increase. DOD supports mathematical research in such areas as vehicle and weapons control, manpower planning and logistics scheduling, reliability and quality control, command control systems, remote sensing and surveillance, strategic planning, information systems, and intelligence, and other scientific investigations that rely on mathematical and statistical methods.

The Pentagon has been by far the largest supporter of computer research on college campuses. NSF figures indicate that for FY 1986, DOD provided $61 million or 54 percent of all Federal funding for computer research. However, a recent report of a panel of the Federal Coordinating Council on Science, Engineering, and Technology Panel (FCCSET) indicates that NSF's data may actually understate DOD's dominance in crucial areas of information science research.[46] According to the FCCSET report, between FY 1983 and FY 1985, DOD provided 60 percent of the $440 million in Federal support to colleges and universities for advanced computer research. NSF was a distant second with $133 million or 30 percent of the total. Further, during the same three year time period, the Federal Government will fund a total of $122 million for very high performance computer research (i.e., research related to the development and use of supercomputers) at colleges and universities. Of that total the Pentagon will provide $74.5 million and NSF $28.7 million, or 61 percent and 24 percent of the total respectively.

According to a recent Office of Technology Assessment (OTA) report, DARPA is the major Federal supporter of Artificial Intelligence (AI) research.[47] OTA estimates that in FY 1983 the Federal Government spent between $27.2 and $34.6 million on AI research, with DOD contributing 70 percent and NSF 18 percent of the funding.[48] These figures do not include funding for DARPA's strategic computing program. In FY 1984, DARPA obligated 43 percent or $21 million to colleges and universities for AI research related to its strategic computing program.[49]

Finally, to help the Pentagon with its current and future software needs, the DOD established in December of 1985 the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI will operate as a federally funded research and development center with an annual budget of approximately $25 million. DOD has estimated that in the near future they could devote up to 10 percent of their entire budget on software needs. Much of this increased need is due to the strategic defense initiative.

DOD is the largest Federal sponsor of engineering research at colleges and universities, providing $219 million in FY 1986, or 38 percent of total Federal support. In a number of specific engineering fields, the Pentagon supports an even greater share of research. In aeronautical and electrical engineering the military provides 60 percent and 57 percent of all Federal research funds to the Nation's colleges. The DOD is the largest supporter of mechanical and materials engineering research obligating 44 percent and 48 percent of all Federal funds respectively.

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[46] Report of the Federal Coordinating Council on Science, Engineering, and Technology Panel on Advanced Computer Research in the Federal Government, June 1985. p. A-1 and A-2.

[47] U.S. Congress. Office of Technology Assessment. Information Technology R&D Critical Trends and Issues. Washington, 1985.

[48] OTA report, p. 94.

[49] Strategic Computing, First Annual Report. DARPA, Feb. 1985. p. 7.

DOD sponsored research in fluid mechanics centers around understanding and modeling turbulence, developing computational fluid dynamics methods for steady and time-dependent flows, and understanding steady and time-dependent separated flows. Engineering research in structures provides the basis for the design of DOD systems, including methodology for stress analysis, modeling of material behavior, life prediction, and failure prediction under a broad range of loading environments.

In the area of materials research, DOD focuses its work on a number of broad application areas such as ships, missile structures, machinery and propulsion systems, and advanced fiber optics for communications. For example, DOD is looking at new composite materials for future aircraft that will "sustain higher temperatures so that less cooling is needed for the avionics system . . . and materials that would result in an airframe that would be higher loaded aerodynamically, that is, have higher strength to weight." [50] Other research concerns involve lighter radar absorbing composite materials for the stealth bomber and tread materials for the M-1 tank that will not wear out until 350 to 400 miles of use.

The SDI program will also place high demands on the Pentagon's research programs in materials and tribology (the study of friction and wear on surfaces and coatings). SDI will require advances in materials such as carbon-carbon and metal-matrix composites, experiments on hypervelocity, electromagnetic propulsion in space and other aspects in the Pentagon's SDI program. [51] The purpose of such research is to develop a space-based defensive weapon system that uses a rail gun to propel projectiles at offensive missiles. According to a DOD spokesman, the universities will have to play a significant role in all these research areas if these programs are to be successful.[52]

The Innovative Science and Technology (IST) office plans to further increase DOD work with plans to obligate $264 million for SDI research on the Nation's campuses in FY 1986. The IST office has been sponsoring research in such areas as advanced laser design, optical sensors, computer software and hardware design, advanced materials and structures, ultra high speed computing, and advanced rocket interceptor technology. Growing SDI involvement on college campuses intensifies the concerns of some about increased military research dominance in certain fields of science, as discussed below.

## I. Issues Related to DOD Funding R&D at Universities

The following section outlines some of the issues that have recently emerged as a result of DOD's growing research efforts at the Nation's universities:

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[50] Aircraft of the Future, Barbara Weiss, American Metal Market, Nov. 4, 1985: 20.

[51] Brooks, Rosanne.Remember The Space Coupe? American Metal Market, Oct. 7, 1985: p. 16.

[52] Phone conversation with DOD representative Mar. 31, 1986.

(1) What impact will rapid increases in DOD support for research and development at universities have on the nation's campuses?

The universities recognize that the Pentagon currently has the fastest growing budget for R&D. In FY 1987 DOD estimates that it will support $1.5 billion of R&D at colleges and universities, thus surpassing NSF as the second largest supporter of R&D on college campuses. Further, since DOD research grants traditionally involve less paper work and have fewer progress reports, universities appear more willing to accept Pentagon research dollars.

Some observers contend that the great crisis of ideology during the Vietnam War has all but disappeared on the Nation's campuses. However, the growing debate over SDI sponsored research at colleges and universities indicates that this may not be the case. In an attempt to challenge the Pentagon's growing influence on campus, in the summer of 1985, researchers from the University of Illinois, Cornell University, and Ithaca College initiated a campus boycott of all SDI research. The organizers of the boycott, now called the United Campuses to Prevent Nuclear War, have circulated a petition on over 60 college campuses asking researchers not to accept SDI funding. The petition has been signed by over 3,700 science and engineering faculty and other senior researchers and 2,800 graduate students and other junior research staff.[53]

The signers of the petition object to the SDI program on the following grounds: (1) that it is morally wrong to conduct research in an area that could increase the chance of nuclear war; (2) that many scientists are concerned that the acceptance of SDI contracts will be seen by the general public as an endorsement of the SDI program by individual universities; (3) that very few scientists and engineers accept the feasibility of the goal of a perfect shield against nuclear weapons as outlined by President Reagan in 1983; (4) that the SDI program may lead to a false sense of security in the United States' ability to repel a nuclear attack; and (5) that such a large infusion of military funding can divert too many scientists and engineers away from important civilian-related research.

In response to this boycott, 80 scientists and engineers who support SDI's goals and objectives have recently established the Science and Engineering Committee for a Secure World. Acting chairman Frederick Seitz, president emeritus of Rockefeller University, stated that "S.D.I. should not be hastily, unscientifically, or ideologically rejected" without a "thorough evaluation." [54] In fact, DOD has had few problems in finding university researchers who are willing to accept SDI funding. The Pentagon indicates that as of September 30, 1985, it had received 3,000 proposals from university researchers seeking SDI support.[55]

Another area of tensions between DOD and the universities relates to the belief that the Pentagon will eventually place national security restrictions on academic research findings. However, in August of 1985, Dr. James A. Ionson, the director of SDI's Innovative Science and Technology Office, issued a memo to top Defense

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[53] SDI Funds Costly for Science. The Bulletin of Atomic Scientists, Jan. 1986: 28.
[54] The Chronicle of Higher Education, June 18, 1986. 18.
[55] SDI Funds Costly for Scientists. Bulletin of the Atomic Scientists, Jan. 1986: 24.

Department officials, stating that "no restrictions will be placed on the publication of research supported by the IST office on university campuses, unless agreed in advance by contract." [56]

Despite Ionson's memo, many researchers in the academic community contend that classification will probably be a serious point of contention. This concern was echoed by Robert Hughey of the Department of Energy's San Francisco field office, who is reported to have said that security classification could be a problem and that research begun openly might eventually be classified.[57]

It is clear that the growing military presence on university campuses has stirred up some old controversies. University officials have indicated that one way to reduce tensions would be to strike a better balance of Federal support for defense and nondefense R&D. In FY 1980 Federal support for R&D was split evenly, half for defense and half for nondefense. However, by FY 1987 support for defense R&D had climbed to 73 percent of the total Federal R&D budget. Many in the academic community believe that providing a better balance between defense and nondefense R&D (by increasing non defense spending) would infuse more civilian-oriented R&D into the academic research community. This would provide university researchers with a greater diversity of funding sources which are more likely to support civilian-oriented basic research programs:

> (2) In what ways will rising DOD support of research at colleges and universities effect academic research priorities?

Because DOD is concerned with protecting the Nation's security, much of the research it funds has a direct relevance to national security needs. For example, DOD has identified such priority areas as: very high speed integrated circuits, software development, and artificial intelligence. As a result, DOD's support for basic research at colleges and universities is heavily concentrated in such areas as computers, mathematics, engineering, and materials research.

DOD's dominance in these crucial fields of research has raised a number of concerns. For example, a recent Office of Technology Assessment (OTA) study on Information Technology and R&D pointed out that relying on DOD "for funding of information technology R&D may conflict with the pressing demands of international competitiveness and productivity." [58] The OTA report went on to raise additional concerns such as: Will military research siphon off too much talent from civilian applications? Is military research changing the direction of research in information technology in ways that could be disadvantageous for the civilian sector? Are existing efforts to transfer technology from military to commercial applications adequate? [59]

The Defense Advanced Research Project Agency's (DARPA) growing influence in both artificial intelligence (AI) and advanced computer research has raised similar concerns about a potential imbalance between military and civilian support of research. Consequently, there is concern within the scientific and technological community that research aimed at meeting specific DOD mission concerns will not produce "dual-use" technologies (i.e., technologies that have both military and civilian applications). Rather, some argue, DOD supported research will concentrate on areas of technology that focuses only on military needs.

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[56] Memo Sets Policy for Star Wars Publications. Science, Aug. 30, 1985. 843.

[57] Senators and Scientists Object to SDI Costs and Uncertainties. Physics Today, July 1985: 56.

[58] U.S. Congres. Office of Technology Assessment. Information Technology R&D Critical Trends and Issues. Washington, 1985. 294.

[59] Ibid., p. 295.

Robert M. White, President of the National Academy of Engineering, has indicated that military goals are "quite properly set, principally, by military needs." However, he continues by asking "how does that affect the tone and direction of academic research on artificial intelligence? And what are the outcomes vis-a-vis the Japanese programs which have explicit civilian purposes?" [60]

The Pentagon asserts that many of these concerns are unfounded and that based on its past record of DOD research contributions to civilian applications, DARPA is the appropriate entity for sponsoring AI research. DARPA has also indicated that most of its advanced computer research will be performed by universities and will remain unclassified. Further, DARPA contends that the NSF supercomputer program will provide a strong civilian counterbalance in the area of advanced computer research. The DOD also asserts that over the long term, the source of funding does not determine the potential utility of a program's research for civilian applications. Individuals within DOD believe that both DARPA and NSF supported advanced computer research will eventually lead to significant commercial spinoffs:

(3) To what extent will military research at colleges and universities contribute to civilian technological spinoffs?

Dr. Richard D. DeLauer, former Under Secretary of Defense for Research and Engineering, has stated that DOD support of a broadly-based research program will augment the Nation's technological superiority and enhance national security. Dr. DeLauer has pointed out that the military has supported a number of researchers who have received Nobel prizes. For example, the DOD was one of the primary sponsors of laser research long before its potential military or commercial applications were understood. In fact, Professor Nicholas Bloembergen of Harvard University, who shared the 1981 Nobel Prize in physics for research leading to the development of lasers, was supported by DOD. The Pentagon also supported research during the 1950s and 1960s that, it contends, led to integrated circuits, intercontinental missiles, computerized weaponry, vastly improved communications systems, and advances in medical science.[61]

According to the Department of Defense, the support of SDI research has the potential to produce enormous commercial spinoffs. In a *Business Week* article, Dr. James A. Ionson, Director of the SDI Innovative Science and Technology Office, stated "Star Wars will create an industrial revolution. . . ." He pointed out that "gamma-ray lasers designed to cripple missiles could also provide the first three-dimensional images of the nuclei of atoms. . . . "You could actually examine cells, genes, strands of DNA. The possible medical uses are absolutely spectacular." [62] Besides medicine, DOD says SDI research will provide spinoffs in aircraft and vehicle design, astronomy, surveillance of Earth resources, circuit design, communications, space exploration, and electric power.

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[60] The Military's Fat Research Budget. Baltimore Sun, Apr. 9, 1984: p. 2-F.

[61] U.S. Dept. of Defense. Office of the Deputy Undersecretary of Defense for Research and Engineering, Basic Research Programs, 1984. 4.

Despite these claims, many researchers contend there is little opportunity for military research to produce commercial spinoffs because the majority of DOD R&D budget is concentrated in weapons development. A recent DOD document indicates that basic and applied research, or what DOD refers to as its technology base research, had decreased from 22 percent of its total R&D budget in FY 1962 to under 9 percent of its R&D budget in FY 1987.[63] Defense R&D funds spent on the technology base, the research area with the potential for developing the greatest commercial applications, grew only 34 percent from 1980 to 1984, while that for strategic programs (nuclear weapons) increased 350 percent.[64]

Only two percent of DOD's R&D budget is for basic research while other Federal R&D agencies are much higher. Almost 40 percent of the DOD grants and contracts for R&D at universities fall in the category of development.[65] The military is now the largest supporter of development activities on the nation's campuses. Including DOD sponsored FFRDCs at colleges and universities, in FY 1985, NSF estimates that DOD funding for development projects exceeded basic research funding by $175 million. The results of development projects are most likely candidates for security classification and for restriction of presentation or publication than technology based projects. Consequently, this increases concerns about universities' abilities to maintain an atmosphere of openness and to share the results of their work for potential commercial spinoffs.

Lewis M. Branscomb, Vice President and Chief Scientist for IBM, questioned DOD's contention that large R&D budgets provide returns to the civilian economy through spinoffs. Dr. Branscomb noted that "companies outside the defense sector . . . generally discount the spinoff of defense and space research." He indicated that "the process has been referred to as 'dripoff.' " [66]

In his testimony before the House Committee on Science and Technology, Franklin A. Long, Director, Program on Science, Technology and Society, Cornell University recommended that DOD should substantially increase its support for basic research. He testified that "the program should be established and operated from a conviction that the DOD and the nation need more such research, and that the results should be published and available to all." And further, the basic research program "should be clearly independent of the goal-oriented R&D programs of DOD, SDI, and others." [67]

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[62] Why Star Wars is a Shot in the Arm for Corporate R&D. Busines Week, Apr. 8, 1985: 78.

[63] Office of Under Secretary of Defense for Research and Engineering. Directorate for Research and Laboratory Management. Review of FY 1987 Budget Request.

[64] Military Research and the Economy: Burden or Benefit? The Defense Monitor, v. XIV, no. 1, 1985: 2.

[65] Long, F.A. DOD Support of Research in U.S. Universities: Projects and Problems. Testimony before the House Science and Technology Committee, Task Force on Science Policy, Oct. 18, 1985. 9.

[66] The Military's Gluttony for Research. Journal of Commerce, Apr. 18, 1984. 4.

[67] Ibid. Long p. 12, 13.

Long testified that in the short-term, DOD should increase its basic research to 5 percent of its total R&D budget; but perhaps in the long-run the goal might be 7 to 10 percent of total R&D. He asserted that such a program should be the generator of new scientific knowledge.

In a recent article, Eric Bloch, Director of the National Science Foundation, called for a national research strategy. He suggested that nondefense basic research funding be increased 50 percent, with the Federal Government doubling its share. Mr. Bloch also indicated that except for health related research, NSF should be the agency responsible for administering these additional Federal funds.[68]

### (4) What Impact Will DOD's Growing R&D Budget Have On Scientific and Engineering Personnel?

The availability of science and engineering (S&E) personnel is an issue on which the interests of universities, government laboratories, and industry merge. In 1984, there were approximately 1,570 vacant faculty positions at U.S. engineering schools. This figure represents about 9 percent of all engineering faculty positions.[69] The Pentagon, which is a major employer of scientists and engineers trained by U.S. universities, reports that it currently has over 5,000 vacant civilian and military openings for S&E. In 1982 the military was either directly or indirectly responsible for the employment of over 3 million or 16 percent of the entire S&E work force.[70] Concomitantly, about 30,000 students were receiving some type of support from DOD, and about 300 graduate students were the recipients of DOD fellowships. A study conducted by the National Science Foundation projects rapid growth in S&E demand that could result in shortages exceeding 10 percent of the S&E work force in disciplines particularly important to DOD such as: aeronautical engineers, computer specialists, and electronic/electrical engineers.[71]

However, according to Gerold Yonas, former Chief Scientist for the SDI, a recent House Appropriations Committee independent study showed that SDIO requirements do not tax the available U.S. scientific resources. Yonas continued by noting that in a few cases, such as optical science, where only two universities offer Ph.D's there might be some concern.[72] In his testimony, Yonas did not examine how SDI needs might tax other DOD research programs that have high S&E personnel needs. When considering other DOD scientific needs, the DOD-University forum points out that "shortages of both civilian and military S&E personnel within the Defense Department are reasonably well documented . . ." [73] However, a recent Office of Technology Assessment (OTA) report on scientific manpower indicated that "individual disciplines [science and engineering] have shown great ability to grow and shrink as market conditions require." [74]

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[68] Bloch, Eric. Managing For Challenging Times: A National Research Strategy. Issues In Science and Technology, Winter 1986: 20.

[69] Engineering Education. American Society for Engineering Education, Oct. 1984. 51.

[70] Report of the DOD-University Forum. Calender Year 1984. Office of the Under Secretary of Defense for Research and Engineering, Dec. 1984. p. 32.

[71] U.S. National Science Foundation. Projected Response of the Science, Engineering, and Technical Labor Market to Defense and Nondefense Needs: 1982-1987. NSF 84-304. 19.

[72] Yonas, Gerold. The Strategic Defense Initiative Science in the Mission Agencies and Federal Laboratories. Testimony before the Science Task Force, Committee on Science and Technology, Oct. 23, 1985.

[73] Ibid., DOD-University Forum. p. 32.

### (5) How Would DOD Changes in Funding Priorities Affect Its Relationship With Colleges and Universities?

University observers have noted that DOD support for research on the Nation's campuses could be affected by congressional efforts to reduce the growing deficit. If DOD research funds were reduced, as they were in the late 1960s and early 1970s, long-range research would be vulnerable, as military research managers shorten their time horizons, when budgets are tight.

This was demonstrated during the first round of FY 1986 budget sequestration under the Gramm-Rudman-Hollings deficit reduction measure. Because President Reagan chose to "protect" SDI from sequestration, DARPA and DOD's other basic research progams were reduced 9.2 percent and 6.2 percent respectively, rather than 4.9 percent general reduction for defense spending called for by GAO. DARPA's university based research programs usually have longer time horizons than the DOD service programs. Consequently, DARPA's long-range basic research programs may suffer larger cuts than the near term basic research programs funded by the services.

Leo Young, former director of Research and Laboratory Management at DOD, has stated that if DOD were to reduce its funding for basic research, university research funding would suffer. Currently the universities perform half of all basic research funded by DOD, with DOD's intramural research laboratories performing 36 percent. Young pointed out that in periods of declining support, DOD's first priority will be to protect its in-house basic research capabilities. Consequently, any significant reduction in DOD basic research support would result in the universities suffering a disproportionate cut in their funding.[75] This could severely impact research in such areas as artificial intelligence, software development, computer sciences, and materials research.

## J. CONCLUSION

In reviewing the overall relationship between the Department of Defense and the Nation's universities, it is clear that the military has played a vital role in establishing the fundamental mechanisms currently associated with the support of academic science. Following World War II, the need to protect and enhance America's national security was a compelling rationale for sustained congressional support of DOD sponsored university based research. Proponents of DOD research point out that without military sponsorship, large scale publicly financed research may have taken far longer to develop.

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[74] U.S. Congress. Office of Technology Assessment. Demographic Trends and the Scientific and Engineering Work Force, Dec. 1985. p. 5. [brackets added.]

[75] Selected Federal Research and Development Agencies and Programs and the Gramm-Rudman-Hollings Deficit Reduction Act: An Analysis of the Impact on Their FY 1986 Budget. CRS Report No. 86-37, Feb. 7, 1986. p. 26.

Further, it is also true that in the 1950s and early 1960s, DOD dominated and controlled the majority of funds for university based research. However, by the late 1960s, with the maturity and growth of NASA, NSF and DOE's predecessor ERDA, military dominance and influence of university research was diminished.

Many critics of DOD sponsored university research appear not to understand or accept that the Pentagon's responsibility to support research is necessarily aimed at achieving DOD's mission. Further, it is not at all clear that if DOD had not developed a strong research program that those funds would have been directed toward civilian oriented research objectives or toward science or to the universities themselves.

It is understandable that some critics are concerned about the recent rapid rise in defense R&D. From 1980–1985, overall Federal R&D funding for national defense increased 74 percent in constant dollars, while concomitantly, nondefense research decreased by 17 percent, although the nondefense basic research component has actually increased 24 percent, in constant dollars, in the same period. Further, the rapid rise of SDI has rekindled academic concerns that the universities may be emphasizing military aspects of national security at the expense of nonmilitary methods to enhance national well being.

In FY 1986, DOD accounted for over 70 percent of total Federal R&D spending. Some members of the scientific community contend that DOD's growing research needs place an enormous strain on the university research infrastructure. Consequently, some scientists believe the Pentagon is obligated to compensate for this by maintaining strong support (beyond current levels) for university instrumentation as well as for basic research.

It appears that a strong case could be made for increasing DOD's support basic research. As this chapter points out, DOD support of its technology base research (6.1 basic and 6.2 applied research) has declined from 22 percent of DOD R&D in 1962 to less than 10 percent in 1986. During the same time period, DOD basic research has declined from 4.7 percent of total RDT&E to 2.6 percent. Testifying before the House Committee on Science and Technology, Task Force on Science Policy, Franklin A. Long, from Cornell University, suggested that "such funding (basic research) should be established and operated from a conviction that the Pentagon and the Nation needs more such research, with the results published and available to all."[76] Long has suggested, that the increase in DOD support of basic research should be aimed at generating new scientific knowledge, totally independent of the Pentagon's mission oriented basic research programs. However, in his view any increase in DOD basic research funding should not occur at the expense of non-military basic research. Others doubt the feasibility and appropriateness of DOD science mission outside its defense responsibilities. Many in the scientific community contend strong Federal support for university centered basic research is essential if the United

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[76] Long, F.A. DOD Support of Research in U.S. Universities Prospects and Problems. Testimony before the House Committee on Science and Technology Task Force on Science Policy. Oct. 18, 1985. p. 12.

States wants to improve its international scientific and economic competitiveness.

Finally, in DOD university research support, the focus has usually been on basic research. Currently, the largest component of DOD R&D funding to universities is development, comprising 48 percent of the total (including university administered FFRDCs). The Pentagon is a close second to DOE[77] in development funding, providing over 35 percent of the total Federal support of development to universities. This is a recent phenomenon that should be watched carefully, since development projects are often classified thus restricting publication opportunities. Consequently, academic concerns, focusing on how growing DOD development funding might actually detract from the broad mission of the university is understandable.

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[77] Since the majority of DOE's work at universities and their associated FFRDCs is related to weapons development, many scientists contend that the military is by far the largest funder of development work.

# CHAPTER VI

# THE ROLE PLAYED BY THE DOD LABORATORY STRUCTURE IN THE CONDUCT AND SUPPORT OF RESEARCH*

(Note: This chapter was completed in the Fall of 1985 largely using FY 83 data provided by the Department of Defense)

## A. The Setting

The Defense Department's mission of protecting the Nation's security requires that products and processes be available to meet military needs. In pursuit of the effort to furnish appropriate goods and services, science provides fundamental knowledge on which to base further technological development. The Department of Defense laboratories contribute significantly to this endeavor both by performing in-house research and by supporting research at universities associated with the defense effort.[1]

Both basic and applied research are major factors in the scientific enterprise and both are the focus of this chapter. In this setting, basic research is performed to increase U.S. . . . "competence in all fields relevant to identified military problems. It also serves as a part of the base for subsequent exploratory and advanced developments in defense-related technologies as well as for new and improved military functional capabilities." [2] Yet equally vital is the ability to utilize the results of basic research. Additional work is often necessary to refine and develop scientific discoveries to the stage where they can be applied to meet the needs of the Defense Department. Applied research or exploratory development is work ". . . directed toward the solution of broadly defined problems, short of major development programs, with a view to developing and evaluating technical feasibility." [3] This capability within its laboratories enables the Department of Defense to assess technologically-oriented problems, issues, and opportunities.

Extensive time and resources have been invested by the Department of Defense for the purpose of creating and maintaining a laboratory system which can support and foster research and development essential to national security. There are currently 72 in-house laboratories which employ approximately 27,500 scientists and engineers.[4] It has been estimated that 6 percent of the U.S. scientific and engineering workforce is in the Defense Department; a number that expands to 10-12 percent if DOD contractors are included.[5] The laboratories were budgeted at $7.9 billion in FY 83, almost two-thirds of which was utilized for research and development.

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*Prepared by Wendy H. Schacht, Specialist in Science and Technology, Science Policy Research Division.

[1] The designation of DOD in-house R&D laboratory used in this paper is that used by the Department of Defense In: U.S. Dept. of Defense. Office of the Undersecretary of Defense for Research and Engineering. Research Office. Required In-house Capabilities for Department of Defense Research, Development, Test, and Evaluation. Oct. 1, 1980. Washington, 1980. p. 9.

[2] Ibid., p. 9.

[3] Ibid.

[4] U.S. Dept. of Defense. Report on the Technology Base and Support of University Research for the Committee on Armed Services. U.S. Congress. Washington, Mar. 1, 1985. p. 38.

The Department of Defense laboratories perform a wide range of activities involving basic research, applied research, development, prototype construction, and testing. The responsibilities and operations of the individual laboratories differ within and between the components of DOD to reflect the mission requirements of the three services. There are currently 35 Army, 23 Navy, and 14 Air Force laboratories. The research conducted in, and supported by, the laboratories is targeted to defense needs with emphasis on the relevancy to the Defense Department's mission. The type and extent of the basic research conducted is dependent on the laboratory's responsibilities within the DOD structure. (See appendix A of this chapter for a FY 1983 list of laboratories and their mission responsibilities.)

## B. THE RATIONALE FOR RESEARCH

The role of the Department of Defense laboratories in the defense enterprise is explicitly stated throughout the relevant DOD literature. In a Defense Department Instruction on the Research and Development Laboratories, it is noted that "DOD laboratories represent a critical and unique resource for solving the scientific and engineering problems, deficiencies, and needs of the Military Departments." [6] Developing this idea further, the Defense Department reported to Congress:

> . . . a primary purpose of the laboratories is to develop and nurture new technologies to support their missions. The importance of this role for the in-house laboratories—the extension, development, and constant improvement of the technology base underlying all future efforts—is fundamental. . . . It is imperative that the laboratories remain on the cutting edge of technologies critical to future military systems, both through their own research programs and through fostering and synergizing the results of such research, in the academic and industrial segments of the research community.[7]

Thus, the laboratories of the Department of Defense perform and/or support research to insure national security. This research effort is directed primarily toward the identification and development of useful materials, weapons, systems, and processes necessary for defense.

Laboratories are a part of a system of DOD supported organizations, including industry and universities, which are responsible for providing the United States with technological superiority in military matters. They are charged with maintaining "a level of technological leadership that shall enable the United States to develop, acquire, and maintain military capabilities needed for national security." [8a] As noted by Dr. Edith Martin, former Deputy Under Secretary of Defense for Research and Advanced Technology, the United States must rely on our technological advancements and the ability to apply the latest, most sophisticated technology to give the U.S. the military advantage over the Soviet Union with its larger armed forces. In the global balance, it is DOD's intent that technical proficiency can offset the advantages of numerical superiority.[8b]

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[5] Interview with James E. Spates, former Associated Director of Army Research and Technology, June 1985.

[6] U.S. Dept. of Defense. Undersecretary for Research and Engineering. Department of Defense Instruction 3201.3. Mar. 31, 1981. p. 1.

The research performed and supported by the DOD laboratories is generally considered by DOD to be work which cannot effectively and efficiently be accomplished in the private sector. The Department's research needs may be unmet by industry or universities for various reasons including the esoteric nature of the work, insufficient commercial potential, lack of academic interest, cost, and/or unavailability of equipment. Therefore, the laboratories undertake or fund this research to satisfy mission requirements. Government support allows for high-risk projects which are intended to meet Defense Department needs and which may have significant payoffs to the country in the future. Department of Defense laboratories are given the charge to focus on mid- and long-term research activities. A long-range perspective permits stability in the research process and may encourage major innovation.

In-house capabilities may provide for a continuous source of innovation to meet national defense needs and to avoid technological surprise. In pursuit of this, the DOD laboratories have accumulated a wealth of knowledge and expertise which they claim can give continuity to decision-making, provide a "corporate memory" on technological issues, avoid those duplications of effort which may be costly, and allow informed choices to be made. Proficiency in science and engineering within the laboratory system can be utilized for the assessment of DOD needs to be supplied by the private sector. If a high level of technical expertise is maintained, it should promote competition in industry to provide the best products and processes.[9] Development of internal capabilities can permit the Defense Department to be a "smart buyer" of militarily critical goods and services from the private sector. The laboratories generally provide for a supply of trained, skilled, mission-oriented scientists and engineers who can evaluate the products and processes offered by industry to meet defense demands.

Informed assessments of the time frames for achieving technological goals by both the public and the private sectors is another intended objective for the Department's in-house scientific and technological proficiencies. The resident expertise in the laboratories and interaction with the scientific community can enable DOD personnel to monitor advancements in science and technology for relevance of the organization's mission requirements. This is intended to facilitate the making of knowledgeable choices between technical options for reaching DOD military goals and may mitigate the possible waste of valuable resources in pursuit of non-optimum or non-feasible technological objectives. In this manner, the laboratories are supposed to assist in the effective and efficient management of the entire DOD RDT&E enterprise.

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[8a] Department of Defense Instruction 3201.3, op. cit., p. 2.

[8b] Martin, Edith. The DOD Science and Technology Program: Some Management Perspectives. Army Research, Development & Acquisition Magazine. Sept.-Oct. 1983: p. 1.

[9] Required In-House Capabilities for Department of Defense Research, Development, Test, and Evaluation, op. cit., p. 3.

"The rapid identification and exploitation of new technological opportunities . . ." is also the responsibility of the Defense Department's laboratory system.[10] In addition to the on-going innovation taking place within the laboratories, the maintenance of in-house specialists is designed to provide for fast reaction to critical defense needs should this become necessary. Similarly, DOD laboratory support of, and cooperation with, the university research establishment is an attempt to insure an adequate supply of scientists and engineers to meet current DOD requirements and which, given the necessity, could be mobilized in the future. This cooperation has led to frequent exchanges of unclassified information and data which has potential for benefiting both the laboratories and the universities—and the country as a whole.

An additional objective of the Department of Defense to which the laboratories contribute is the development and maintenance of a healthy industrial base.[11] A recent DOD report to the Senate Armed Services Committee underscores the importance of the technolgy base:

> A strong free enterprise economy and industrial base—here and abroad—are the essential underpinnings of our defense posture. Investment in our technology base and maintenance of our technological strength are critical to the long term security of the United States and our allies.[12]

To accomplish this may require innovations which can result from investments in science and technology. Science and technology contribute to the country's economic growth by increasing productivity and by providing new and improved products and processes to meet new and/or previously unmet needs. New processes may allow for more efficient production. New products can assist in meeting defense requirements. New materials may help in reducing our dependence on other nations. A strong economy can provide the resources by which to support further innovations.

## C. Operations

Each Department of Defense laboratory has a specific mission tied to the needs of the respective service. Beyond this, DOD Instruction 3201.3 states that, among other things, the laboratories shall "be delegated as much authority, responsibility, and flexibility as is practicable for the management and utilization of their manpower resources." Decisions on the course of research to be pursued—either in-house or funded by the laboratory and performed in another organization—are often based on determinations of: (1) whether the area of research is relevant to DOD; (2) whether it is "good science"; and (3) whether the research would be performed (within an acceptable time frame) if it were not supported by the Defense Department. Peer review is utilized in the evaluation of basic research projects. Quality is a major factor, but not the sole consideration in funding determinations. Mission relevance and future applicability of the work are also evaluated.

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[10] Ibid., p. 14.
[11] Report on the Technology Base and Support of University Research, op. cit. p. 53.
[12] Ibid., p. 53.

### 1. FUNDING [13]

The laboratories of the Army and the Air Force are institutionally funded. Navy laboratories, however, are funded on a project basis. While certain functions are always kept internal, Navy laboratories must compete with outside institutions for much Navy research and development funding, enter into work agreements with Navy customers, and are paid by project.

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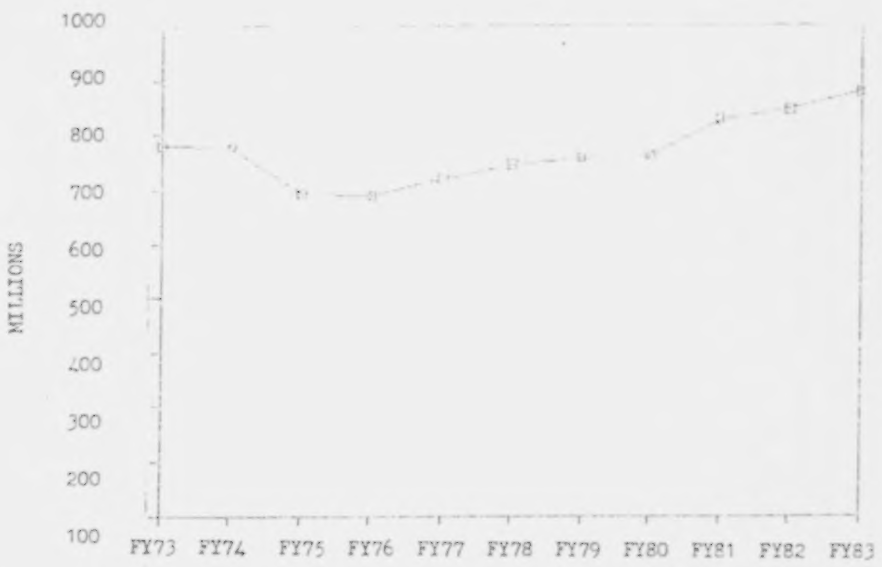
[13] See figures 1-3.

Figure VI - 1

TOTAL DOD LABORATORY 6.1 + 6.2 FUNDING IN CONSTANT DOLLARS FY73-FY83 *



* Source: Based on data supplied by DOD, June 1985.

## Figure VI - 2

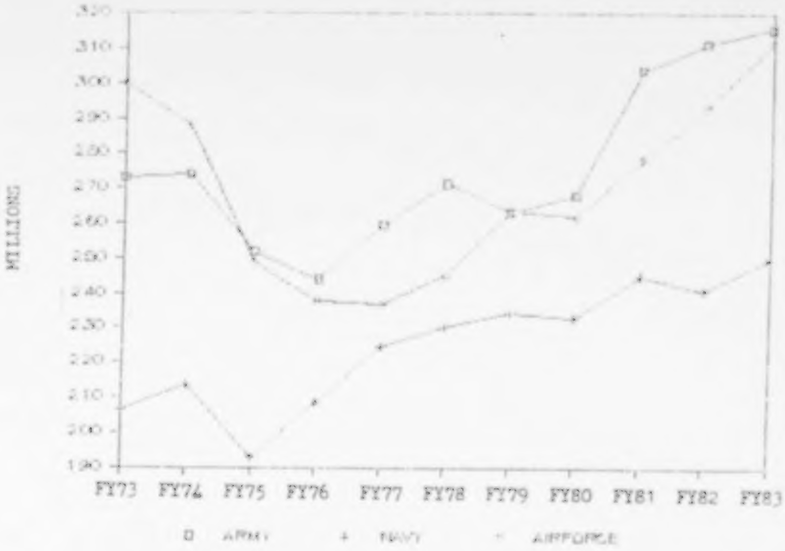
Statistical Information on Department of Defense Laboratories FY73-FY83*

| | FY73 | FY74 | FY75 | FY76 | FY77 | FY78 | FY79 | FY80 | FY81 | FY82 | FY83 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Lab RDTE Budget (thousands)** | | | | | | | | | | | |
| Army | 763,357 | 743,594 | 780,464 | 825,076 | 875,263 | 867,833 | 1,030,747 | 1,222,371 | 1,368,011 | 1,574,137 | 1,744,295 |
| Navy | 741,942 | 744,268 | 818,321 | 960,059 | 1,053,808 | 1,122,749 | 1,296,203 | 1,418,982 | 1,531,129 | 1,683,326 | 1,805,324 |
| Air Force | 537,402 | 542,903 | 713,413 | 699,023 | 945,401 | 1,003,930 | 1,246,258 | 1,300,779 | 1,464,360 | 1,218,048 | 1,388,861 |
| ALL DOD LABS | 2,042,701 | 2,030,765 | 2,312,198 | 2,488,158 | 2,874,572 | 2,994,512 | 3,573,208 | 3,942,132 | 4,365,500 | 4,475,511 | 4,938,480 |
| **Lab 6.1 + 6.2 Budget (thousands)** | | | | | | | | | | | |
| Army | 285,380 | 307,493 | 310,744 | 321,964 | 365,590 | 408,112 | 430,219 | 476,325 | 593,949 | 651,939 | 687,473 |
| Navy | 215,768 | 239,465 | 237,771 | 274,933 | 316,510 | 346,268 | 382,847 | 413,735 | 478,591 | 504,334 | 543,675 |
| Air Force | 313,171 | 323,357 | 306,867 | 313,869 | 333,536 | 368,564 | 430,837 | 465,112 | 543,774 | 613,558 | 679,066 |
| ALL DOD LABS | 814,319 | 870,315 | 855,382 | 910,766 | 1,015,636 | 1,122,944 | 1,243,903 | 1,355,172 | 1,616,314 | 1,769,831 | 1,910,214 |
| **Lab 6.1 + 6.2 Budget Constant 1972 Dollars (thousands)** | | | | | | | | | | | |
| Army | 273,352 | 274,302 | 252,023 | 244,093 | 259,652 | 271,532 | 263,131 | 268,201 | 304,121 | 311,485 | 315,934 |
| Navy | 206,674 | 213,617 | 192,839 | 208,440 | 224,794 | 230,385 | 234,157 | 232,959 | 245,054 | 240,962 | 249,851 |
| Air Force | 299,972 | 288,454 | 248,878 | 237,960 | 236,886 | 245,219 | 263,509 | 261,887 | 278,430 | 293,148 | 312,071 |
| ALL DOD LABS | 779,999 | 776,374 | 693,740 | 690,497 | 721,332 | 747,135 | 760,797 | 763,047 | 827,606 | 845,593 | 877,856 |
| **Lab 6.1 + 6.2 as % Lab RDTE** | | | | | | | | | | | |
| Army | 37 | 41 | 40 | 39 | 42 | 47 | 42 | 39 | 43 | 41 | 39 |
| Navy | 29 | 32 | 29 | 29 | 30 | 31 | 30 | 29 | 31 | 30 | 30 |
| Air Force | 58 | 60 | 43 | 45 | 35 | 38 | 35 | 36 | 37 | 50 | 49 |
| ALL DOD LABS | 40 | 43 | 37 | 37 | 35 | 38 | 35 | 34 | 37 | 40 | 39 |
| **Out-House 6.1 + 6.2 as % of In-House 6.1 + 6.2** | | | | | | | | | | | |
| Army | 73 | 84 | 63 | 64 | 64 | 58 | 57 | 64 | 104 | 93 | 84 |
| Navy | 24 | 25 | 31 | 36 | 50 | 49 | 58 | 59 | 64 | 71 | 68 |
| Air Force | 114 | 123 | 121 | 142 | 145 | 151 | 153 | 180 | 215 | 186 | 321 |
| **Lab 6.1 + 6.2 as % DOD RDTE** | | | | | | | | | | | |
| ALL DOD LABS | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 |
| **Lab 6.1 + 6.2 as % DOD 6.1 + 6.2** | | | | | | | | | | | |
| ALL DOD LABS | 57 | 62 | 61 | 60 | 61 | 62 | 62 | 60 | 62 | 60 | 59 |

* Based on data supplied by DOD, June 1985.

Figure VI - 3

ARMY, NAVY, AIR FORCE LABORATORY 6.1 + 6.2 FUNDING IN CONSTANT DOLLARS FY73-FY83 *



* Source: Based on data supplied by DOD, June 1985.

Analysis of the available data (fiscal years 1973 and 1983) indicate that, in constant dollar terms, the amount of funding for Department of Defense laboratory 6.1 and 6.2 work has increased 27 percent since FY76, an average yearly growth rate of approximately 3 percent. The largest increase in support occurred between fiscal years 1980 and 1981. The increased DOD support for 6.1 and 6.2 activities in FY80 and beyond appears to reflect a policy decision made in a 1979 Defense Department budget statement which called for real growth in the technology base to maintain the technological leadership of the United States.

In the years studied, approximately 61 percent of the technology base activities supported by the Department of Defense were performed in, or funded by, the DOD laboratories, ranging from 57 to 62 percent in any given year. There was approximately four times as much 6.2 work undertaken by the laboratories as 6.1 basic research. The Army and the Air Force consistently supported higher levels of 6.1 and 6.2 laboratory funding than the Navy.

Laboratory support for technology base activities remained virtually constant at 10 percent of the total DOD funding for RDT&E between fiscal years 1973 and 1981. In FY82 and FY83 it decreased to 9 and 8 percent respectively. During the similar time period, total DOD tech base funding as a percent of total DOD RDT&E ranged from a high in FY73 of approximately 18 percent to a low in FY83 of 14.5 percent, with the largest declines occurring between fiscal years 1973 and 1975 and fiscal years 1980 and 1983.

As might be expected given their mission responsibilities, the laboratories expend a greater portion of their RDT&E budget on technology base work than the Department of Defense as a whole. In the period between fiscal year 1973 and fiscal year 1983, laboratory 6.1 and 6.2 support ranged between 34 and 43 percent of the total laboratory RDT&E budget. In contrast, the total Defense Department 6.1 and 6.2 funding comprised only 14.5 to 17 percent of total DOD RDT&E spending.

While the major portion of the DOD laboratories RDT&E budget was utilized for specific, identified research and development efforts, laboratory directors have access to a certain amount of discretionary funding to support additional, non-targeted basic and/or applied research. According to the Department, discretionary funds are ". . . to be used for investments in scientific areas the directors deem important, or to increase laboratory expertise in selected technical areas."[13] Discretionary funding in the Army totals approximately 10 percent of the basic research program. No such money is available for applied research activities. Within the Air Force, discretionary funds equal about seven percent of the basic research budget and in FY85 a similar program was initiated in applied research. The Navy has discretionary funding for both basic and applied research activities which amounts to approximately 2 percent of the laboratories' budget. Expressing concern at this low figure, the Navy indicated in its response to the Office of Science and Technology's Report on Federal Laboratories (the Packard

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[13] U.S. Executive Office of the President. Office of Science and Technology Policy, Progress Report on Implementing the Recommendations of the White House Science Council's Federal Laboratory Review Panel v. II. Washington, U.S. Govt. Print. Off., July 1984, p. 21.

Report) an attempt would be made to increase such funding to ". . . attract highly qualified scientists and engineers and to help develop and retain a sound course of in-house expertise."[14]

Similarly, the President's Private Sector Survey on Cost Control (the Grace Commission) recommended that laboratory directors have increased flexibility over the allocation of funds within their laboratories.[15] Because of delays associated with the budget process, it was determined that more efficient management and utilization of resources could be achieved by permitting laboratory directors increased discretion over internal use of laboratory money.

### 2. EXTRAMURAL RESEARCH SUPPORT

While the laboratories themselves perform research and development in-house, they also fund research at other institutions. This is accomplished with the intention of ensuring that the best technical developments are pursued by combining and utilizing the strengths of the laboratories, universities, and industry. Over one-half of the DOD laboratory RDT&E budget goes to other organizations to fund projects where there are limited commercial markets or where there is little academic interest but which are considered important to national defense. These projects are managed by laboratory personnel and the amount of funding directed at extramural research is increasing. This may be diverting laboratory technical personnel from "tech base" activities to contract monitoring.

According to the FY83 figures the Air Force supports the greatest amount of extramural research; the Navy the least. Since the mid-1970s, there has been a sharply increasing amount of laboratory technology base funds directed to work outside these laboratories. Prior to that time, the effects of the Vietnam war and the Mansfield Amendment caused a significant increase in the proportion of basic research performed in the laboratories. There was an attempt to stem this increase in the mid-1970s when a 30/70 inhouse/out-of-house ratio was adopted for reasons which remain unclear.[16] Under the Reagan Administration, the stated policy of reducing in-house basic research was dropped. However, since the current administration's focus is on promoting basic research in universities, the amount available to the laboratories for in-lab work has decreased.

### 3. PERFORMANCE EVALUATION

Laboratory performance is evaluated in various ways, both formal and informal. A Laboratory Management Task Force was created in 1979 and is composed of individuals who are familiar with the laboratories and their respective missions. The approach of this group is to identify changes which could increase the laboratories' contributions to the missions responsibilities of the Department of Defense. In the separate services, review can be random as a response to special needs. Other reviews are scheduled and are often tied to DOD budget requests. Budget competition often instigates various different reviews either by line item or by organization. Generally the assessments are subjective rather than quantitative, and peer group review appears to be the most effective.[17] Feedback on laboratory performance is also achieved by responses from project managers, other laboratories, other services, headquarters, and/or interaction at technical conferences.

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[14] Ibid., p. 19.

[15] President's Private Sector Survey on Cost Control. Task Force Report on Research and Development. Jan 15, 1984, p. 72.

[16] Berman, Alan. DOD In-House Basic Research. In Proceedings of an AAAS Symposium on Jan. 8, 1980; How Much Does the Defense Department Advance Science? Washington, Naval Research Laboratory. NRL Rept. 8426, p. 7-8.

The Grace Commission noted that each service has its own review mechanisms and that there was no on-going process for evaluating the DOD laboratories.[18] Both the Grace Commission and the USDRE (Under Secretary for Defense Research and Engineering) Independent Review of DOD laboratories came to the conclusion that systematic assessment of the laboratories was necessary. This review process would, according to advocates, provide visibility for in-house work and provide information as to the scope and direction of the laboratories' research activities.[19]

### 4. LABORATORY-COMMAND INTERACTION

A lack of communication between laboratory researchers and the operational commands was identified as a barrier to DOD effectiveness early in the Reagan administration. In order to identify the type of research and development necessary to meet service requirements, it is necessary for the laboratories to interact with the military support and funding commands. However, as the 1982 review of DOD laboratories by the Under Secretary of Defense for Research and Engineering found:

> The laboratories have great difficulty understanding and representing what will be needed by operational forces. . . . Functions which are integrated with and imbedded in the command structure such as communications, command and control, electronic warfare, and the battlefield applications of intelligence have suffered through lack of adequate means of technology applications. These functions demand not only the ability to rapidly adapt to new technology but also the need for combined operational-technical competence in integrating these new technologies into operational doctrine and concepts. The laboratories are organized along the lines of engineering functions, platforms, or commodities and are not well equipped to address these problems.[20]

On the other hand, the operating commands often are not able to assess and project the use of technological opportunities. "The existing procedures for developing and stating required operational capabilities are . . . inadequate to project the nature of military operations ten and twenty years into the future in language useful for making technology management decisions."[21] This failure of communications and interaction between the operating commands and the laboratories apparently has lead to a situation where the Department of Defense has ". . . not effectively applied many of the new and potentially high leverage technologies which have been available over the past two decades." [22]

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[17] Interview with James E. Spates, former Associate Director of Army Research and Technology, June 1985.

[18] Task Force Report on R&D, op. cit., p. 72.

[19] Hermann, Robert J. USDRE Independent Review of DOD Laboratories, Washington. Under Secretary of Defense Research and Engineering, Mar. 22, 1982, p. 4-18/4-19.

[20] Ibid., p. 3-6.

[21] Ibid., p. 4-21.

The Office of the Secretary of Defense has established a task force to improve cooperation and the transfer of information and needs. To date, there are a number of ongoing efforts to facilitate laboratory-command interaction. These activities include, but are not limited to:

(1) The Army Material Command placing scientists in field units to identify problems with technological solutions and maintaining on-site liaison at Army training centers and schools.

(2) The Navy placing approximately 30 scientists and engineers, on a rotating basis, within the operational commands under the auspices of the Navy Science Assistance program. The Marine Corps assigning officers to all major Navy R&D activities.

(3) The Air Force having its chief scientists meet twice a year at locations of the operating forces and requiring the Air Force Logistics Command, the Air Force Systems Command and the operational commands to develop formal documents identifying R&D objectives and logistics and research needs.[23]

### 5. CHAIN OF COMMAND

The chain of command is one factor in determining the extent of the interaction between the laboratories and the operating commands. Decisions regarding laboratory research activities can be affected by the position of the laboratory in the chain of command relative to the operating divisions. The composition of this chain through which the laboratories report and receive instructions generally affects ways in which the laboratories operate. In an organization, the closer to the top level of the decision-making process the more input can be contributed and influence exerted as decisions are made. Reporting to a higher level in the command chain can provide laboratories with visibility and pull in decision-making. Policy and personnel determinations are made through these channels.

The Air Force noted in its response to the Packard Report that it had "recently" reorganized service laboratories by placing them in product divisions ". . . to promote closer ties between the research community and the research users." [24] The Air Force laboratories all report to the Air Force Systems Command and the Chief of Staff through the appropriate divisions, with the exception of the Engineering Services Center which reports through Headquarters staff.

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[22] Ibid., p. 3-5.

[23] Progress Report on Implementing the Recommendations of the White House Science Council's Federal Laboratory Review Panel. 1984. Op. cit., p. 24.

[24] Ibid., p. 17.

The Navy has also made several recent alterations in the chain of command.[24a] In the first of these, the Chief of Naval Material was abolished and the three laboratories in the systems command were assigned to report directly to the Chief of Naval Operations. Nine other laboratories which were previously under the Chief of Naval Material, which are considered major laboratories in terms of funding levels, and which focus on exploratory development activities, were placed under the auspices of the Chief of Naval Research. Here they joined the three laboratories which directly reported to the Chief of Naval Research and which spend the major portion of their funds on basic research. According to advocates of this reorganization, it was designed to bring closer together both the Navy's basic research and technology development activities to achieve greater coordination and utilization of the results of basic research.

However, this new organization was apparently unsatisfactory. The nine laboratories which had been placed under the Chief of Naval Research had staff approximately five times as large as the organization they were joining. There were difficulties integrating the large number of people into the existing management and operational structure. Consequently, these nine laboratories which perform primarily applied research were placed into a systems command—the Naval Electronics System Command—which was renamed the Space and Warface Systems Command. The Space and Warface Systems Command was expected to assume a new and important status. What appears evident is that an extra layer of reporting has been added. When these nine laboratories reported directly to the Chief of Naval Material (which was abolished in the first of these two recent reorganizations) they were reporting to a four star Admiral. Under the current system, these laboratories report to a three star Admiral and are removed one additional step from the top decision-makers.

The Army instituted a change in the chain of command in October 1985.[24b] Several laboratories previously associated with the R&D and the Material Commands now report to a new Laboratory Command. The Army Corps of Engineers and the medical laboratories remain as they were in the former command chain. This reorganization was designed, according to the Army, to foster improved coordination, faster response to identified problems, and a better exchange of information.

### 6. PERSONNEL AND MANPOWER

Over the years there have been numerous studies of the operation of the Department of Defense Laboratories. Personnel and manpower factors have consistently been identified as major issues in need of attention and improvement.[25] The conduct of research in DOD laboratories is affected by policies and practices concerning the tenure of laboratory directors. The directors of the laboratories have both policy and leadership responsibilities. Until recently, civilian directors did not rotate jobs which allowed for continuity in decision-making and the development of an institutional memory. This arrangement has potential for providing an environment conducive to the pursuit of research which is often long-term and high risk in nature. However, military directors of the laboratories rotated every three to four years which diminished familiarity with laboratory orientation and operation. This has potential adverse affects on the conduct of research if the policy process internal to the laboratory does not promote the continuity which can be provided by a permanent director and which is often necessary to undertake long-range, high risk efforts.

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[24a] Information based on 1986 conversations with Navy laboratory staff.

[24b] Information based on 1986 conversations with the Office of Army Research and Technology.

[25] Report on the Technology Base and Support of University Research, op. cit., p. 48–49.

Recent directives in both the Army and the Navy now require that civilian, as well as military, Technical Directors rotate. This has resulted in a turnover at the top position as various Directors have left the services to pursue outside opportunities. It has been argued that Technical Directors remain in their Government laboratories despite better pay in the private sector because they feel that their particular job offers a rewarding experience. It might be expected that these Directors of Federal laboratories, with their abilities and status, would have moved if they so desired. Forcing a change to a position which is not requested appears to diminish the perceived benefits of Government service and makes private sector employment more attractive. Given the problems encountered in keeping highly qualified scientists and engineers in the Federal Government, it is difficult to see how mandatory rotation of Technical Directors will help the research process within the Department of Defense.

The July 1980 report of the DOD Laboratory Management Task Force stated that "without doubt manpower ceiling reductions have been the greatest single factor negatively impacting the contributions of the laboratories over the past 15 or so years." [26] The number of slots for scientific and engineering personnel within the DOD laboratory system has declined over the years. While there was an increase in personnel between fiscal years 1973 and 1975, after 1975 the number of technical employees began to decline despite rising funding levels for technology base work within the laboratories. In addition, congressionally mandated ceilings on high level laboratory employees have made it difficult to promote scientists and engineers. Thus, it has been argued, the laboratories of the Defense Department have become, in essence, a training system for technical personnel in industry and academia as Federal employees move on to more lucrative positions in the private sector.[27]

There are other issues surrounding compensation for scientists and engineers. Within the Federal Government, those laboratories which are owned by the Government but which are operated by contractors (GOCOs) can offer technical personnel prevailing wage rates and thereby attempt to remain competitive with industry in attracting the best talent. None of the Department of Defense laboratories are GOCOs; thus the technical staff is paid according to Government scales which are often substantially below that which a trained scientist or engineer would receive in the private sector. Compounding this is the fact that military and civilian employees of DOD laboratories have different pay rates and benefits. Thus, scientists or engineers doing the same job may receive different compensation. In both cases, this salary is generally less than that paid to an employee at a Government-owned, contractor-operated laboratory or in industry.

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[26] Report of the DOD Laboratory Management Task Force. Washington, Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology), July 1980, p. 17.

[27] DOD In-House Basic Research, op. cit., p. 13.

Lower pay scales and promotion barriers might be expected to be a disincentive to obtaining the best research staff. If the Department of Defense wants to attract and keep the most qualified personnel in the long-run, it is reasonable to expect that there might be some mechanism to alleviate the wage disparities. In recognition of this, the Department has considered the option of creating a separate personnel management system with more competitive compensation rates and procedures for scientists and engineers. This approach was recommended in various reports including the USDRE Independent Review of DOD Laboratories (March 1982), the Report of the DOD Laboratory Management Task Force (July 1980), and the Report of the White House Science Council on Federal Laboratories (May 1983). A test program was conducted at the Naval Weapons Center at China Lake and the Naval Oceans System Center in San Diego.

### 7. TECHNOLOGY TRANSFER

In addition to funding research in other institutions, the laboratories of the Defense Department are involved in transferring nonclassified scientific and technical expertise outside the Government where it can be utilized for defense-related or civilian purposes. Department of Defense facilities often have state of the art equipment which is unavailable or inaccessible elsewhere. In order to make maximum use of this, DOD policy is to permit universities to use laboratory facilities when they are not being utilized for mission-related work. Private companies can use the resources of the laboratories when the labs ". . . possess unique facilities not available in the private sector." [28]

Additional interactions with universities and the private sector are accomplished through a variety of mechanisms. Information is exchanged through the Defense Technical Information Center, the National Technical Information Service of the Department of Commerce (unclassified), and the 21 DOD Information Analysis Centers. The Defense Technical Information Center (DTIC) is in the Defense Logistics Agency and is part of the Scientific and Technical Information Program. It provides access to scientific and technical information through an on-line system which includes all published reports (classified and unclassified) from defense contractors and laboratories as well as lists of research projects in progress. The unclassified reports are also provided to NTIS where they can be further distributed. Users of this Center include other Federal agencies, laboratories, DOD contractors, and "potential" contractors.

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[28] Progress Report on Implementing the Recommendations of the White House Science Council's Federal Laboratory Review Panel, op. cit., p. 21-22.

There are 21 DOD Information Analysis Centers, 11 which are contractor-operated for the Administrator of DTIC and 10 of which are in-house.[28a] These Centers are in the major "technical thrust areas" determined by the Under Secretary of Defense for Research and Engineering and provide information and assistance which is more detailed than that available through the DTIC on-line system. The information and technical assistance stresses access to experts who are knowledgeable in a subject area in addition to the provision of references. If long-term assistance is necessary there may be a requirement for reimbursement. The rationale is to provide state-of-the-art data and to prevent inefficient duplication of research already completed or ongoing. In the past, the non-internal IACs were located at universities and large non-profit institutions. Recently for-profit organizations have been included. Users include DOD personnel, other Government agencies, Government contractors, and the public if resources are available and security considerations are met. FY86 funding for these centers has also been cut.

Cooperation with the private sector is also achieved through laboratory participation in the evaluation of the Industrial Independent Research and Development program. In addition, the laboratories assist in screening and evaluating proposals as requested for the Department of Defense's Small Business Innovation Research effort.

The Department of Defense laboratories were in the forefront of the effort to transfer scientific expertise and technology from the Federal Government to State and local governments and the private sector. The organization which is now known as the Federal Laboratory Consortium for Technology Transfer, with approximately 300 Federal laboratory members, was originally established under the auspices of the Department of Defense in June 1972. Its origin can be traced to a July 1971 meeting when, at the suggestion of the Special Assistant to the Deputy Director for Research and Advanced Technology, representatives from 11 DOD laboratories met informally in an attempt to coordinate their efforts to transfer military-related technologies to the civilian sector. The resulting Technology Transfer Laboratory Consortium, which was authorized in a policy memorandum issued by the Deputy Secretary of Defense in June 1972, was ". . . formed for the purposes of coordinating interactions with other Federal agencies and technology users as Federal, State, and local levels, and coordinating civil sector work being performed for others."[29] These operating procedures were redefined in a memorandum for the Assistant Secretaries of the Military Departments (R&D) by the Director of Defense Research and Engineering, dated June 14, 1974, the year that the DOD program was expended into the Federal Laboratory Consortium for Technology Transfer to include other Federal departments and agencies. The Department of Defense continues to support the

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[28a] Information based on conversations with staff of the Defense Technical Information Service.

[29] Operating policy of the Department of Defense Technology Transfer Laboratory Consortium issued June 21, 1972.

Consortium; until 1986 the Army provided significant funding and DOD personnel are actively involved and are in many leadership positions.

In 1980, the Stevenson-Wydler Technology Innovation Act was signed into law mandating, among other things, that the Federal Government promote the transfer of technology to State and local governments and the private sector, as the DOD laboratories had been doing for the previous eight years. On April 15, 1983, the Army issued Regulation 70-57 which provides policies and operation guidelines for military-civilian technology transfer in response to Stevenson-Wydler. At the departmental level, DOD has formulated a policy concerning the domestic transfer of non-classified technology and scientific expertise from the laboratories to other sectors to meet the requirements of section 11 of P.L. 969-480. DOD Regulation 3200.12-R-4, dated April 1985, establishes the Defense Department's domestic technology transfer program under the responsibility of the Under Secretary of Defense for Research and Engineering. This document states that it is the policy of the Department of Defense to support the domestic transfer of technology to foster innovation consistent with the requirements of national security. It directs each appropriate DOD laboratory to establish an Office of Research and Technology Applications as required by P.L. 96-480 and directs these offices to carry out the activities as specified in the law.

## D. CONCLUDING OBSERVATIONS

"The technology environment surrounding the laboratory has changed profoundly in the past two decades," according to a March 1982 review of the DOD laboratories. There is an increasing amount of technology which is relevant to defense; there is added competition with the private sector for technology and trained personnel; and there are wider options for the application of technologies which are more complex today.[30] Laboratories offer a unique resource to the Department of Defense. Generally they are equipped to undertake activities that range from basic research to product development; all designed to meet the mission requirements of DOD. In performing these functions, the DOD laboratories have played a major role in the development of the technology base as indicated by both the amount of funding and the extent of basic and applied research undertaken. Over an 11 year period, FY 1973 to FY 1983, approximately 61 percent of the technology base activities supported by the Defense Department were performed by or funded by the laboratories. While there was approximately four times as much 6.2 applied work performed as 6.1 basic research within the laboratories, this still constitutes a significant contribution to the conduct and support of all research. This research has led to many military-related accomplishments. In the civilian sector, DOD R&D has resulted in, among other things, the development of the artificial kidney, typhoid and smallpox vaccines, computer hardware and software, masers, lasers, and commercial aircraft technologies (see chapter XIII for more discussion on commercial applications).

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[30] USDRE Independent Review of DOD Laboratories, op. cit., p. 3-1.

The DOD laboratories also contribute to the support of research through their interaction with universities and industry. A growing proportion (over half) of the laboratory 6.1 and 6.2 budget is utilized to contract work at other institutions. This can be a catalyst for an expanded amount of work throughout the U.S. research system. It also assists laboratory personnel in keeping up to date on new ideas in scientific and engineering fields. However, contracting out work means that more time and effort must be expended in monitoring such activities, thus diminishing the time and financial resources of the staff for in-house research. Laboratory support of research within industry and academia, as well as the balance and composition of such efforts, has effects which require further examination.

It was expected that the emphasis by the Reagan Administration on basic research and the development of the technology base would improve the climate for work in the laboratories. However, there continues to be issues which have been identified as obstacles to laboratory research productivity. Many of these have to do with personnel and management concerns. The rotation of Technical Directors can adversely affect the conduct of research if the decision-making process internal to the laboratory does not promote the continuity often necessary to undertake long-range activities, or if mandatory changes induce capable Directors to leave the services. Maintenance of an adequate supply of scientists and engineers is also essential to the performance of 6.1 and 6.2 efforts and the Defense Department has had continuing problems in this area. The number of slots for scientific and technical personnel within the laboratories has generally been declining. In addition, the pay scales for such employees are often substantially below those in the private sector, making it dificult to attract the best and brightest candidates. Compounding this is the fact that military and civilian employees within the laboratories receive different compensation and benefits. The flexibility in personnel matters afforded to Government-owned, contract-operated laboratories does not exist in DOD facilities and may, in the long-term, hurt the Department's effort to develop a strong technology base.

Other concerns have been expressed related to the performance of the laboratories. Newer and more up-to-date equipment and facilities were seen as necessary to improve the research capabilities. What has also been proposed is greater coordination of research efforts between and within the services. The development of centers of excellence to work in major research areas is one suggestion made by the Grace Commission. The concept is to amass a critical amount of resources devoted to a particular research program.[31] While some duplication of effort is both necessary in and beneficial to a research effort the size of that conducted by DOD, coordination of information on research activities are necessary. There are currently several endeavors underway to achieve this coordination; the Federal Laboratory Consortium provides an informal information network and the Defense Technical Information Service gathers data on ongoing and completed work. However, to be effective these programs must be utilized, which often requires initiative by the individual researcher or the laboratory director. Without clear guidance from top management there is the potential that these and other coordination mechanisms will not be used. Additional means for coordinating the research in the laboratories and between laboratories and the operating commands may also be necessary.

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[31] Task Force Report on Research and Development, op. cit., p. 71.

In addressing the issues, the following questions might be considered:

1. Since the laboratories perform such a substantial amount of technology base research, are they being adequately staffed and funded to meet current and projected needs?
2. Can pay scales for DOD military and civilian scientists and engineers be made competitive with private industry?
3. Are more slots needed for scientists and engineers in DOD laboratories? Can the Department of Defense attract sufficient numbers of talented individuals to fill these slots?
4. Should all laboratory directorships be made permanent to encourage continuity of operation and decisionmaking?
5. Are the positions of the laboratories in the individual Service chain of command optimum for decision-making regarding the development of the technology base?
6. How can the technology transfer process be facilitated so that technologies developed the laboratories can be utilized to provide improved products and processes in the civilian sector and thus promote the strong industrial base necessary for national security?
7. Is there sufficient interaction and exchange of ideas and information between laboratories within, and between, the Services?
8. Does the basic research in the DOD laboratories translate more efficiently and effectively into products and processes necessary to meet military needs than basic research funded by DOD and performed in industry or academia?

# APPENDIX A

(EXCERPTS FROM:)

# DEPARTMENT OF DEFENSE IN-HOUSE RDTE ACTIVITIES

30 October 1983

Prepared for:

US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 Eisenhower Avenue
Alexandria, Virginia 22333

TABLE 1A. ARMY R&D LABORATORIES, PROGRAM AND PERSONNEL DATA, FY 1983

| INSTALLATION | FUNDING DATA (MILLIONS $) |  |  |  | PERSONNEL DATA |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | TOTAL | TOTAL INHOUSE | TOTAL RDT&E | INHOUSE RDT&E | TOTAL MIL | TOTAL CIV | PHD MIL | PHD CIV | PROF MIL | PROF CIV |
| AEROMEDICAL RESEARCH LABORATORY | 9.947 | 8.858 | 7.701 | 6.612 | 79 | 78 | 16 | 8 | 38 | 19 |
| ATMOSPHERIC SCIENCES LABORATORY | 31.223 | 28.588 | 28.208 | 17.573 | 101 | 341 | 0 | 29 | 3 | 110 |
| AVIATION RESEARCH & TECHNOLOGY LABORATORIES | 86.204 | 30.991 | 80.413 | 27.573 | 16 | 359 | 1 | 27 | 13 | 258 |
| AVIONICS R & D ACTIVITY | 34.844 | 13.231 | 28.851 | 5.250 | 17 | 261 | 0 | 6 | 11 | 162 |
| BALLISTIC RESEARCH LABORATORY | 69.553 | 54.737 | 58.629 | 44.503 | 25 | 691 | 0 | 111 | 8 | 414 |
| BELVOIR R & D CENTER | 306.159 | 49.854 | 106.095 | 39.399 | 71 | 1178 | 1 | 27 | 66 | 399 |
| CHEMICAL R&D CENTER | 138.210 | 79.665 | 102.490 | 57.920 | 95 | 983 | 6 | 71 | 39 | 596 |
| COLD REGIONS R&E LABORATORY | 19.630 | 14.280 | 18.858 | 6.968 | 15 | 263 | 0 | 34 | 3 | 125 |
| COMBAT SURVEILLANCE & TGT ACQUISITION LAB | 37.971 | 9.567 | 24.344 | 7.816 | 12 | 167 | 0 | 3 | 8 | 98 |
| COMMUNICATIONS - ELECTRONICS R & D CENTER | 151.451 | 47.690 | 118.497 | 35.908 | 73 | 551 | 0 | 14 | 22 | 362 |
| CONSTRUCTION ENGINEERING RESEARCH LAB | 23.998 | 15.631 | 19.445 | 12.506 | 11 | 208 | 0 | 29 | 11 | 141 |
| ELECTRONIC WARFARE LABORATORY | 170.437 | 31.049 | 92.926 | 22.855 | 84 | 483 | 1 | 6 | 75 | 206 |
| ELECTRONICS TECHNOLOGY AND DEVICES LAB | 74.685 | 19.962 | 68.325 | 17.682 | 1 | 291 | 0 | 48 | 1 | 184 |
| ENGINEER TOPOGRAPHIC LABORATORIES | 45.883 | 12.990 | 42.883 | 10.983 | 14 | 286 | 1 | 18 | 8 | 169 |
| ENGINEER WATERWAYS EXPERIMENT STATION | 91.750 | 77.073 | 29.329 | 25.647 | 23 | 1538 | 1 | 101 | 23 | 590 |
| FIRE CONTROL & SMALL CAL. WPNS SYSTS LAB | 104.091 | 83.676 | 40.830 | 27.812 | 14 | 650 | 0 | 28 | 14 | 415 |
| HARRY DIAMOND LABORATORIES | 134.185 | 62.486 | 68.872 | 37.426 | 6 | 1169 | 0 | 48 | 6 | 362 |
| HUMAN ENGINEERING LABORATORY | 18.729 | 14.378 | 14.977 | 10.998 | 35 | 179 | 1 | 18 | 10 | 117 |
| INSTITUTE OF DENTAL RESEARCH | 4.479 | 3.735 | 2.526 | 1.782 | 82 | 21 | 1 | 2 | 24 | 11 |
| INSTITUTE OF SURGICAL RESEARCH | 8.592 | 7.834 | 4.144 | 3.386 | 157 | 79 | 16 | 4 | 46 | 31 |
| LARGE CALIBER WEAPONS SYSTEMS LAB | 187.453 | 133.167 | 120.064 | 66.974 | 27 | 1734 | 1 | 82 | 19 | 1050 |
| LETTERMAN ARMY INSTITUTE OF RESEARCH | 16.521 | 13.065 | 12.242 | 8.786 | 158 | 117 | 33 | 14 | 97 | 51 |
| MATERIALS AND MECHANICS RESEARCH CENTER | 46.445 | 24.495 | 40.722 | 19.698 | 16 | 610 | 1 | 73 | 19 | 238 |
| MEDICAL BIOENGINEERING R&D LABORATORY | 17.080 | 6.666 | 15.992 | 5.578 | 33 | 103 | 2 | 17 | 25 | 47 |
| MEDICAL R & D COMMAND | 15.164 | 14.362 | 12.118 | 11.316 | 61 | 148 | 29 | 1 | 55 | 2 |
| MEDICAL RESEARCH INSTITUTE CHEMICAL DEFENSE | 37.818 | 17.005 | 35.239 | 14.426 | 85 | 159 | 33 | 22 | 47 | 69 |
| MEDICAL RSCH INST OF INFECTIOUS DISEASES | 34.564 | 23.081 | 27.916 | 16.433 | 305 | 285 | 46 | 41 | 104 | 92 |
| MISSILE LABORATORY | 258.460 | 104.426 | 177.053 | 69.028 | 45 | 1170 | 4 | 70 | 31 | 776 |
| NATICK R & D CENTER | 67.733 | 55.417 | 47.813 | 36.859 | 108 | 1092 | 3 | 77 | 40 | 391 |
| NIGHT VISION & ELECTRO OPTICS LABORATORY | 172.289 | 32.036 | 75.088 | 25.614 | 32 | 478 | 0 | 39 | 6 | 216 |
| RESEARCH INST FOR BEHAVIORAL & SOCIAL SCI | 50.239 | 19.132 | 39.892 | 17.537 | 31 | 374 | 0 | 166 | 30 | 271 |
| RSCH INSTITUTE OF ENVIRONMENTAL MEDICINE | 7.145 | 6.508 | 5.516 | 4.879 | 77 | 97 | 6 | 18 | 39 | 59 |
| SIGNALS WARFARE LABORATORY | 105.954 | 8.495 | 46.056 | 5.739 | 51 | 180 | 0 | 5 | 18 | 93 |
| TANK-AUTO COMMAND R & D CENTER | 697.659 | 35.282 | 101.149 | 24.194 | 36 | 554 | 0 | 14 | 21 | 218 |
| WALTER REED ARMY INSTITUTE OF RESEARCH | 67.280 | 48.344 | 53.062 | 34.126 | 411 | 598 | 82 | 59 | 386 | 278 |
| TOTALS | 3343.825 | 1199.756 | 1744.295 | 781.786 | 2484 | 17219 | 285 | 1322 | 1350 | 8620 |

INSTALLATION: AEROMEDICAL RESEARCH LABORATORY FT.RUCKER,AL.

CDR COL DUDLEY R. PRICE DEP CDR LTC J.D. LAMOTHE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 7.701 | 8.244 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.004 | 0.004 |
| TOTAL OTHER | 2.242 | 2.202 |
| TOTAL ANNUAL LAB | 9.947 | 10.450 |
| TOTAL INHOUSE | 8.858 | 9.507 |
| TOTAL INHOUSE RDT&E | 6.612 | 7.301 |
| ANNUAL OPERATING COST | 8.118 | 8.005 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 79 | 16 | 30 | 49 |
| CIVILIAN | 78 | 8 | 19 | 59 |
| TOTAL | 157 | 24 | 49 | 108 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 54 | 98.255 | 20.000 | 18.351 | 136.606 | 7.612 | 12.285 |

...MISSION

CONDUCTS LIFE SCIENCES RSCH INTO AVIATION,COMBAT VEH, & COMBAT WEAPONS SYS ENV & THEIR EFF ON CREWMEMBERS HLTH, SAFETY & PERF. DATA BASES ACQUIRED THRU FLD & LAB RSCH.INSTITUTES IN RSCH ON THE BIOEFFECTS OF LASER SYS,DEF AGST CML AGTS,OPNS USED TO IMPROVE MEANS OF PATIENT EVACUATION.

...CURRENT IMPORTANT PROGRAMS

EFFECTS OF NERVE AGENT ANTIDOTES ON THE VISUAL SYSTEM
INDIVIDUAL AND CREW EFFICIENCY ENHANCEMENT
AUDITORY EFFECTS OF BLAST OVERPRESSURE
VIBRATION HAZARDS OF COMBAT AIRCRAFT AND VEHICLES
BIOEFFECTS OF COMBAT MATERIEL AND OPERATIONS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MULTI AXIS VIBRATION SYS,HELICOPTER INFLIGHT MONITORING SYSTEM W/INSTRUMENTED RANGE,ANECHOIC & REVERBERATION CHAMBERS,MOBILE ACCOUSTICS LAB, AIRCRAFT MODIFIED FOR INFLIGHT MED RSCH,VIVARIUM,SINGLE AXIS VIBRATION SYS,DATA ACQUISITION & BIOTELEMETRY SYS, ELECTRON & LIGHT MICROSCOPY LAB FIELD RSCH FACILITY,ANALOGUE & DIGITAL COMPUTER SYS, IMPACT FACILITY, SCIENTIFIC & MED RSCH INFORMATION CENTER, SPECTROGRAPHIC ANALYSIS SYS, CARDIOPULMONARY LAB, BIO OPTICAL TESTING LAB, VISUAL NEUROPHYSIOLOGY LAB OPTICAL FABRICATION LAB, SHOCK TUBE, ELECTRO OPTICAL TESTING LAB, HIGH PRESSURE LIQUID CHROMOTOGRAPHY

INSTALLATION: AIR DEFENSE BOARD EL PASO,TX.

PRES. COL. RUSSELL M. MCGRAW TECH. ADV. MR. CHARLES E. FRENCH

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 4.825 | 5.373 |
| TOTAL PROCUREMENT | 1.122 | 0.498 |
| TOTAL O&M | 1.901 | 0.996 |
| TOTAL OTHER | 8.438 | 4.168 |
| TOTAL ANNUAL LAB | 10.786 | 11.035 |
| | | |
| TOTAL INHOUSE | 7.808 | 8.885 |
| TOTAL INHOUSE RDT&E | 3.684 | 4.630 |
| ANNUAL OPERATING COST | 0.653 | 0.737 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 102 | 0 | 6 | 96 |
| CIVILIAN | 88 | 0 | 12 | 76 |
| TOTAL | 190 | 0 | 18 | 172 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 29.172 | 37.090 | 19.132 | 85.394 | 1.189 | 14.781 |

...MISSION

PLAN, CONDUCT AND REPT ON OPERATIONAL AND OTHER USER TESTS. PARTICIPATE IN OTHER TESTING AS DIR. PROV ADVICE AND GUIDN ON TEST MATTERS TO COMBAT TRAINING, AND MAT DEVELOPERS, OTHER SERVICES AND PRIVATE INDUSTRY. CONDUCT OTHER TESTS AND SELECTED SPECIFIC EVAL AS DIR BY CG TRADOC.

...CURRENT IMPORTANT PROGRAMS

BFV-FOT
PIVADS
SGT YORK (DVT)
SGT YORK IPT
SHORAD C2.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

EQUIPMENT: MULTIPLE TGT TRACKING SYS PROVIDES DATA FROM AIR AND GROUND TGTS, TWO LASER TRACKING SYS PROVIDE DATA FROM COOPERATIVE TGTS; INSTR WITH RADAR DATA RECORDER; A RANGE TIMING SYS TO PROVIDE A TIME BASE FOR RADAR SYS THAT PROVIDES HIGH ACCURACY; ONE NIKE-HERC FIRE CON SYS USED FOR RANGE SAFETY; TECH PHOTO LAB FOR REQUIRED DATA; RICS PROVIDES NEAR REAL TIME DATA OUTPUTS. FACILITIES AT FT BLISS: BLDG 1656 HOUSES RICS; RANGE TIMING SYS; DATA REDUCTION SYS: ELECTRONICS CAL & FABRICATION LAB; ALL INSTR SYS; TWO DATA ACQ SYS ACCEPT 59 DIFFERENT SIGNALS, CCTV SYS MACHINE & CARPENTER SHOPS; MICROWAVE TERMINAL THAT PROVIDES DATA & COMMO LINK TO RANGES; BLDG 1658 - PHOTOGRAPHIC LAB; DONA ANA, MCGREGOR, NORTH MCGREGOR RANGES FOR FIRING FORWARD AREA WEAPONS AT AIR OR GROUND TGTS. SITE MONITOR FOR ELECTRONICS TESTING OF EQUIPMENT.

INSTALLATION: ARMOR AND ENGINEER BOARD FT.KNOX,KY.

PRES. COL. CECIL L. SHRADER SCI. ADV. MR. WARREN W. WELLS

| PROGRAM | PROGRAM DATA BY FISCAL YEAR (MILLION $) | |
|---|---|---|
| | 1983 (ACTUAL) | 1984 (ACT + EST) |
| TOTAL RDT&E | 6.877 | 10.005 |
| TOTAL PROCUREMENT | 1.057 | 8.110 |
| TOTAL O&M | 0.456 | 0.812 |
| TOTAL OTHER | 4.217 | 4.400 |
| TOTAL ANNUAL LAB | 12.107 | 17.827 |
| TOTAL INHOUSE | 12.107 | 17.827 |
| TOTAL INHOUSE RDT&E | 6.877 | 10.005 |
| ANNUAL OPERATING COST | 0.696 | 0.794 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 197 | 0 | 74 | 123 |
| CIVILIAN | 100 | 1 | 21 | 79 |
| TOTAL | 297 | 1 | 95 | 202 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 2 | 63.365 | 50.454 | 88.069 | 201.888 | 1.455 | 5.904 |

...MISSION
PLAN CONDUCT & REPORT: OTI,II,III,FDTE,CEP,PIP,& OTHER USER TESTS OF AR/ENGR EQ. PARTICIPATE IN SPEC STUDY OF CML EQ. PROVIDE GUIDANCE/ADVICE TO DEVELOPERS, PRODUCERS & OTHER SVCS/PRIVATE INDUSTRY. PLAN/COORDINATE RPT ON PERFORMANCE TESTS OF TEST BED VEHICLES & ADVANCED TECHNOLOGIES.

...CURRENT IMPORTANT PROGRAMS
SURROGATE RESEARCH VEHICLE
EVASIVE TARGETRY
ADVANCED TECHNOLOGY RESEARCH
ARMORED COMBAT EARTH MOVER
INSTRUMENTATION DEVELOPMENT.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
VIDEO AUTOMATIC TARGET TRACKING SYS; SIMFIRE HIT-KILL INDICATOR;POSITION LOCATION SYS; WIRE GUIDED EVASIVE TARGET SYS; TANK VIDEO SYS;GUN CAMERA; RANGE TIMING EQ; TELEMETRY EQ; 16MM MOTION PICTURE CAMERA W/DATADOORS; THRU-TANK-OPTICS VIDEO DEVICE;GUN ELEVATION LIMITING DEVICE; SLR CAMERA; AUTOMATIC FILM ANALYZER & DIGITIZER SYS; DATA ANALYSIS & RECORDING SUBSYS;VIDEO I;VIDEO II;METEROLOGICAL INSTRUMENTATION;MICROCOMPUTER DEVELOPMENT LAB; AUTOMATIC TARGET SCORING SYS; DIGITAL VIDEO PROCESSOR;BT-41 DIRECT COMBAT WEAPON SIMULATOR. ADP CAPABILITIES INCLUDE IN-HOUSE REDUCTION & ANALYSIS OF INSTR GENERATED DATA, TELECOMMUNICATIONS INTERFACE TO CD & T&E NETWORK & CLASSIFIED PROCESSING. 40 TON OVERHEAD CRANE; MACHINE SHOP & MAINT EQ SETS; CBT VEH, TACTICAL WHLD VEH & ENGR CONSTRUCTION EQ, ELEVATED CAMERA PLATFORM.

INSTALLATION: ARMY RESEARCH OFFICE DURHAM,N.C.

DIR. DR. ROBERT E. WEIGLE SCI. ADV. DR. HERMANN R. ROBL

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 85.857 | 92.000 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.076 | 0.106 |
| TOTAL ANNUAL LAB | 85.933 | 92.106 |
| | | |
| TOTAL INHOUSE | 0.076 | 0.106 |
| TOTAL INHOUSE RDT&E | 0.000 | 0.000 |
| ANNUAL OPERATING COST | 1.888 | 2.100 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 2 | 0 | 2 | 0 |
| CIVILIAN | 125 | 89 | 89 | 86 |
| TOTAL | 127 | 89 | 41 | 86 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 6 | 0.000 | 26.500 | 0.000 | 26.500 | 0.000 | 0.633 |

...MISSION

TO MANAGE THE ARMY'S RESEARCH PROGRAM RELEVANT TO ARMY MISSIONS IN MATH AND PHYSICAL,ENGINEERING,ENVIRONMENTAL AND LIFE SCIENCES ACCOMPLISHED THRU CONTRACTS AND GRANTS WITH EDUCATIONAL AND RESEARCH INSTITUTIONS AND GOVERNMENT AND INDUSTRIAL LABS IN CONUS AND OVERSEAS.

...CURRENT IMPORTANT PROGRAMS

RESEARCH IN ARTIFICIAL INTELLIGENCE.
CHEMICAL AND BIOLOGICAL DEFENSE.
ROTARY WING AIRCRAFT RESEARCH.
DIRECTED ENERGY RESEARCH.
NOVEL NONDESTRUCTIVE EVALUATION.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

ADMINISTRATION OF RESEARCH PROGRAMS IN PHYSICAL SCIENCES MATHEMATICS, MATERIAL, ELECTRONICS, MECHANICS AND AERONAUTICS. ADMINISTRATION OF THE RESEARCH PORTION OF ARMY RESEARCH AND STANDARDIZATION OFFICE, LONDON, COORDINATES ARMY RESEARCH EFFORTS WITHIN THE ARMY AND WITH OTHER GOVERNMENT AGENCIES SUCH AS NAVY, NASA, DOD, DOE, NSF AND OTHERS.

INSTALLATION: ATMOSPHERIC SCIENCES LABORATORY WHITE SANDS MR,N.M.

CDR. DIR. LTC. RONAN I. ELLIS DEP. DIR. MR. JAMES E. MORRIS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 28.208 | 31.849 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.019 | 0.022 |
| TOTAL OTHER | 2.996 | 1.695 |
| TOTAL ANNUAL LAB | 31.223 | 33.566 |
| | | |
| TOTAL INHOUSE | 20.588 | 20.265 |
| TOTAL INHOUSE RDT&E | 17.573 | 18.548 |
| ANNUAL OPERATING COST | 6.011 | 6.751 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 181 | 0 | 3 | 178 |
| CIVILIAN | 341 | 29 | 110 | 231 |
| TOTAL | 522 | 29 | 113 | 409 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 15 | 49.467 | 26.663 | 85.658 | 161.788 | 7.477 | 23.757 |

...MISSION

TO PROVIDE THE US ARMY WITH SYSTEMS, TECHNIQUES AND EXPERTISE IN THE ATMOSPHERIC SCIENCES NECESSARY TO WIN THE AIRLAND BATTLE. THE ATMOSPHERIC SCIENCES LABORATORY IS RESPONSIBLE FOR THAT PORTION OF THE ERADCOM MISSION DEVOTED TO RESEARCH IN THE ATMOSPHERIC SCIENCES.

...CURRENT IMPORTANT PROGRAMS

TACTICAL WEATHER INTELLIGENCE AND ATMOSPHERIC SENSING ON THE BATFLD
ATMOSPHERIC EFFECTS ON DIRECTED ENERGY WEAPONS
BATTLEFIELD ATMOSPHERIC EFFECTS ON ARMY SYSTEMS AND OPERATIONS
METEOROLOGICAL DATA SYSTEM, AN/TMQ-31, FOR ARTILLERY
METEOROLOGICAL SUPPORT AND TECHNOLOGY FOR ARMY RDTE

...FUNCTIONS/EQUIPMENT/CAPABILITIES

DOD NATIONAL HIGH ENERGY LASER SYSTEM TEST FACILITY
MULTISPECTRAL IMAGE DATA ACQUISITION SYSTEM (MIDAS)
SIMULTANEOUS MULTISPECTRAL ABSOLUTE RADIOMETER/TRANSMISSOMETER (SMART)
TRANSPORTABLE ATMOSPHERIC CHARACTERIZATION STATION (TACS)
METEOROLOGICAL RDTE SUPPORT FACILITIES - ALASKA TO CANAL ZONE
UPPER ATMOSPHERE RESEARCH AND SOUNDING ROCKET FACILITY AND CAPABILITY
VISIOCEILOMETER (VISIBILITY/CLOUD SENSOR) PARTICLE MEASUREMENT SYSTEM
(PMS) LOW VISIBILITY INFRARED (LOVIR) TRANSMISSOMETERS LASER DOPPLER
VELOCIMETER (REMOTE VERTICAL SOUNDER - WIND MEASUREMENTS)
TARGET AREA MET UTILIZING INFERRED MET DATA (WIND/VISIBILITY) FROM RPVS
METEOROLOGICAL DATA SYSTEM, AN/TMQ-31
LIDAR SYSTEMS (1.06 MICRONS ND:YAG AND 10.6 MICRONS CARBON DIOXIDE)

INSTALLATION: AVIATION BOARD FT.RUCKER,AL.

PRES. COL. ROBERT A. WAGG, JR TECH. ADV. MR. G. E. SLAGLEY

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 5.322 | 3.579 |
| TOTAL PROCUREMENT | 0.834 | 0.208 |
| TOTAL O&M | 0.052 | 1.027 |
| TOTAL OTHER | 2.325 | 2.441 |
| TOTAL ANNUAL LAB | 8.533 | 7.255 |
| TOTAL INHOUSE | 7.911 | 7.255 |
| TOTAL INHOUSE RDT&E | 5.322 | 3.579 |
| ANNUAL OPERATING COST | 1.690 | 2.130 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 79 | 0 | 26 | 53 |
| CIVILIAN | 38 | 1 | 9 | 29 |
| TOTAL | 117 | 1 | 35 | 82 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 0.000 | 18.826 | 20.470 | 39.296 | 0.000 | 1.141 |

...MISSION

TO PLAN, CONDUCT AND REPORT ON OPERATIONAL TEST I,II AND IIA FOR NONMAJ AND OTHER TESTS AS DIRECTED BY HQ TRADOC. AVN BD DESIGNS AND CONDUCTS TESTING AND EVALUATION OF AVIATION SYSTEMS, SUBSYSTEMS AND ANCILLIARY EQUIPMENT.

...CURRENT IMPORTANT PROGRAMS

F0328 SCOUT I
OTN1019 NAP-OF-THE-EARTH COMMUNICATION (NOE)
CEP084 LIQUID METHANE FUEL
4000534 AIRBORNE TARGET HANDOFF SYSTEM (ATHS)
OTN849 HELICOPTER OXYGEN SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

NO MAJOR EQUIPMENT OR FACILITY.

INSTALLATION: AVIATION DEVELOPMENT TEST ACTIVITY FT. RUCKER,AL.

CDR. COL WILLIAM B. WOODSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 10.223 | 8.379 |
| TOTAL PROCUREMENT | 3.021 | 2.728 |
| TOTAL O&M | 2.345 | 2.216 |
| TOTAL OTHER | 3.376 | 3.662 |
| TOTAL ANNUAL LAB | 18.965 | 16.985 |
| | | |
| TOTAL INHOUSE | 18.965 | 16.985 |
| TOTAL INHOUSE RDT&E | 10.223 | 8.379 |
| ANNUAL OPERATING COST | 7.427 | 8.150 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 143 | 0 | 26 | 117 |
| CIVILIAN | 93 | 0 | 27 | 66 |
| TOTAL | 236 | 0 | 53 | 183 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1196 | 0.000 | 41.218 | 130.776 | 171.994 | 1.473 | 28.885 |

...MISSION
PLAN,CONDUCT,AND REPORT ON TESTS OF AVIATION SYSTEMS AND AVIATION RELATED EQUIPMENT FOR THE ARMY. PLAN, CONDUCT AND REPORT ON TESTS OF AVIATION SYSTEMS AND AVIATION RELATED SUPPORT EQUIPMENT FOR NON-ARMY GOVERNMENT AGENCIES AND PRIVATE IND

...CURRENT IMPORTANT PROGRAMS
ARMY HELICOPTER IMPROVEMENT PROGRAM (AHIP)(OH-58D)
ADVANCED ATTACK HELICOPTER PROGRAM (AH-64)
LOGISTICAL EVALUATION - CH-47D
UH-60 HIRSS HOVER SUPPRESSOR
LOGISTICAL EVALUATION - UH-60 ESSS

...FUNCTIONS/EQUIPMENT/CAPABILITIES
TWENTY-EIGHT FIXED AND ROTARY WING AIRCRAFT ARE ASSIGNED (8 UH-1,3 CH-47 6 OH-58, 1 OV-1, 1 U-21, 5 AH-1, 1 T-42, 1 UH-60 AND 2 TH-55) WHICH MAY BE USED AS TEST BEDS FOR ALL COMPONENTS, EQUIPMENT OR SUPPLIES APPLICABLE TO THAT SERIES. A MODULAR ENGINE TEST SYSTEM (METS) PROVIDES ACCURATE MEASUREMENTS OF TURBINE ENGINE PERFORMANCE FOR ENGINES UP TO 5000 HP & WT UP TO 2000 LB. AN OVER-WATER RANGE IS AVAIL FOR RELIABILITY TESTING OF A/C WPNS SYSTEMS. ON-SITE DATA PROCESSING AND DISPLAY CAPABILITY EXISTS WITH A PDP-11 & IBM 4331 COMPUTER SYS. ADMIN & TECH PHOTO CAP ARE AVAIL TO INCL VIDEO & 16MM INSTRUMENTATION CAMERAS. ANALOG AND DIGITAL MEASUREMENTS CAN BE COLLECTED, USING 14-TRACK INSTR RECORDERS. USAAVNDTA HAS B&W & COLOR VIDEO RECORDING CAP, AS WELL AS STRIP-CHART & OSCILLOGRAPH RECORDERS & AIRINC 514 AIRLINE-TYPE CRASH RECORDERS.

INSTALLATION: AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB,CA.

CDR. COL ALAN R. TODD TECH. DIR. MR. JAMES S. HAYDEN

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 7.283 | 7.654 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 1.414 | 1.555 |
| TOTAL ANNUAL LAB | 8.697 | 9.209 |
| TOTAL INHOUSE | 8.196 | 8.723 |
| TOTAL INHOUSE RDT&E | 6.782 | 7.168 |
| ANNUAL OPERATING COST | 2.079 | 2.183 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 65 | 0 | 24 | 41 |
| CIVILIAN | 100 | 0 | 32 | 68 |
| TOTAL | 165 | 0 | 56 | 109 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 19 | 9.200 | 1.600 | 124.800 | 135.600 | 4.042 | 26.977 |

...MISSION

PRODUCE ENGR FLT TEST DATA ON ACFT PERF,HANDLING QUALITIES VIBRATION SYS/SUBSYSTEM INTERFACE FOR USE IN ACFT DEVELOPMENT AND QUALIFICATION. SUSTAIN THE CAPABILITY TO COMPLETELY INSTRUMENT TEST ACFT WITH ONBOARD RECORDING/TELEMETRY REAL TIME DATA REDUCTION. CONDUCT PRE-TPS ORIENT.

...CURRENT IMPORTANT PROGRAMS
UH-1H PNEUMATIC BOOT DEICING
CH-47D AIRWORTHINESS AND FLIGHT CHARACTERISTICS
PAE UH-60A/INPROVED A/S SYSTEM
PAE UH-1H HOVER DEGRATION/ROTOR ICIND
PAE AND AIRWORTHINESS AND FLIGHT CHARACTERISTICS UH-60A ESSS

...FUNCTIONS/EQUIPMENT/CAPABILITIES
JT-28B 2T-28B OV-1C JU21A JAHIS 2JCH-47C JOH-58C JUH-60A 5JUH-1H
ACFT MAINTANENCE CAPABILITY
ACFT MODIFICATION CAPABILITY
ACFT INSTRUMENTATION CAPABILITY
AIRBORNE DATA ACQUISITION-SYSTEM
IEMR COMPUTER WITH TELEMETRY
3REMOTE GROUND STATIONS WITH COMPUTER AND TELEMETRY CAPABILITY
MILIKEN,2MINOLTA,2BRONICA,PRINT DRYER,2ENLARGERS 16PCS VIDEO EQUIP
2TEXT EDITORS,2MAG TYPEWRITERS,AUTO COMPOSING SYSTEM.

INSTALLATION: AVIATION RESEARCH & TECHNOLOGY LABORATORIES MOFFETT FIELD,CA.

DIR. DR. RICHARD M. CARLSON DEP. DIR. COL. WALTER URBACH, JR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 80.413 | 80.250 |
| TOTAL PROCUREMENT | 3.718 | 14.157 |
| TOTAL O&M | 1.235 | 0.500 |
| TOTAL OTHER | 0.838 | 1.437 |
| TOTAL ANNUAL LAB | 86.204 | 96.344 |
| | | |
| TOTAL INHOUSE | 80.991 | 87.356 |
| TOTAL INHOUSE RDT&E | 27.573 | 29.757 |
| ANNUAL OPERATING COST | 6.111 | 7.655 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 16 | 1 | 13 | 8 |
| CIVILIAN | 859 | 27 | 258 | 101 |
| TOTAL | 875 | 28 | 271 | 104 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 127 | 88.848 | 58.673 | 16.370 | 163.891 | 2.272 | 17.001 |

...MISSION

MANAGE AND EXECUTE RESEARCH AND DEVELOPMENT OF ARMY AIRMOBILE SYSTEMS. PROVIDE TECHNICAL SUPPORT TO PROJECT/PRODUCT MANAGERS AND SYSTEM DEVELOPERS AS REQUIRED. PROVIDE INDEPENDENT TECHNICAL RISK ASSESSMENT TO COMMANDER USAAVSCOM AND HIGHER AUTHORITY.

...CURRENT IMPORTANT PROGRAMS

RSCH IN FUNDAMENTAL ROTOR/ROTORCRAFT AERODYNAMICS, DYNAMICS, AND NOISE.
R&D OF ENGINES, SMALL GAS TURBINES, TRANSMISSIONS, AND BEARINGS.
R&D TO IMPROVE RELIABILITY & MAINTAINABILITY OF AIRMOBILE SYSTEMS.
RSCH COMPOSITES & EVALUATE APPLICATIONS TO IMPROVE STRUCTURES FOR A/C.
EVOLVE TECHNOLOGY & CRITERIA TO IMPROVE FLIGHT SAFETY & SURVIVABILITY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THREE LABORATORIES — AT MOFFETT FIELD CA, CLEVELAND OH, HAMPTON VA; CO-LOCATED WITH NASA; PARTICIPATING IN AERONAUTICAL RESEARCH AND DISCIPLINES; JOINTLY USING WIND TUNNELS, SIMULATORS AND LABORATORY TEST FACILITIES, INCLUDING SHOPS, FLIGHT LINE AND HANGER, ENGINE AND TRANSMISSION TEST FACILITIES AND COMPUTATIONAL EQUIPMENT. FOURTH LABORATORY AT FORT EUSTIS VA, PERFORMING ADVANCED APPLICATIONS WORK INCLUDING AIRCRAFT WEAPONIZATION AND MISSION SUPPORT EQUIPMENT. MAJOR EQUIPMENT AND FACILITIES ARE FILAMENT WINDING MACHINES, TENSILE TESTERS, VIBRATION TESTER, SMALL BALLISTIC RANGE, CALIBRATION LAB, ENVIRONMENT CHAMBER, ATOMIC ABSORPTION SPECTROMETER, TELEMETER GROUND STATION, NON-DESTRUCT TESTING FACILITY, AND FLIGHT SAFETY LAB.

INSTALLATION: AVIONICS R & D ACTIVITY FT.MONMOUTH,N.J.

CDR. COL. DARROLD GARRISON DEPUTY DIR. MR. THEODORE SUETA

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 20.851 | 17.249 |
| TOTAL PROCUREMENT | 5.506 | 3.757 |
| TOTAL O&M | 6.301 | 5.636 |
| TOTAL OTHER | 2.186 | 2.290 |
| TOTAL ANNUAL LAB | 34.844 | 28.932 |
| | | |
| TOTAL INHOUSE | 13.231 | 13.600 |
| TOTAL INHOUSE RDT&E | 5.250 | 5.720 |
| ANNUAL OPERATING COST | 4.359 | 4.073 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 17 | 0 | 11 | 6 |
| CIVILIAN | 261 | 6 | 162 | 99 |
| TOTAL | 278 | 6 | 173 | 105 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 52.450 | 13.140 | 19.100 | 84.690 | 0.000 | 10.781 |

...MISSION

RESPONSIBLE FOR THAT PORTION OF AVSCOMS MISSION WHICH PERTAINS TO AVIONICS FROM RESEARCH THRU FIRST TIME PRODUCTION. THIS ENCOMPASSES: SYS ARCHITECTURE;AVIONICS HARDWARE;(I.E. COMM NAV,IMAGE AND SIGNAL PROCESSING,AIRBORNE CMD AND CONTROL);AND SYS ENGINEERING/INTEGRATION.

...CURRENT IMPORTANT PROGRAMS

ARMY DIGITAL AVIONICS SYSTEM.
INTEGRATED INERTIAL NAVIGATION SYSTEM.
ADVANCED DIGITAL COMMUNICATIONS.
NIGHT NAVIGATION AND PILOTAGE SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MAJOR EQUIPMENT INCLUDES DIGITAL HOT BENCH,AUTOMATED DATA COLLECTION AND REDUCTION EQUIPMENT, AND AUDIO/DIGITAL ANALYZERS.
FACILITIES INCLUDE ACOUSTIC/AUDIO ANALYSIS FACILITY,TACTICAL AVIONICS SYSTEM SIMULATOR (TASS), SYSTEM TEST BED FOR AVIONICS RESEARCH (STAR), COMPUTER AIDED DESIGN/ENGINEERING,(CAD/E) FACILITY, AVRADA PRODUCT ASSURANCE AND COMPUTATION FACILITY,ADJACENT HELIPORT,PLANNED POST DEPLOYMENT SOFTWARE SUPPORT CENTER.

INSTALLATION: BALLISTIC RESEARCH LABORATORY ABERDEEN PROV.GR.,MD

DIR. DR. ROBERT J EICHELBERGER DEP. DIR. COL JAMES V. WASSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 58.629 | 60.800 |
| TOTAL PROCUREMENT | 1.082 | 1.200 |
| TOTAL O&M | 1.653 | 1.795 |
| TOTAL OTHER | 8.189 | 8.500 |
| TOTAL ANNUAL LAB | 69.553 | 72.295 |
| | | |
| TOTAL INHOUSE | 54.737 | 56.915 |
| TOTAL INHOUSE RDT&E | 44.503 | 46.139 |
| ANNUAL OPERATING COST | 11.143 | 11.905 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 25 | 0 | 8 | 17 |
| CIVILIAN | 691 | 111 | 414 | 277 |
| TOTAL | 716 | 111 | 422 | 294 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1920 | 511.780 | 11.200 | 40.982 | 563.962 | 15.426 | 47.949 |

...MISSION

ARMY LEAD LAB FOR BALLISTIC TECHNOLOGY,VULN/VULN REDUCTION, CHARGED PARTICLE BEAM TECH AND LIQUID PROPULSION TECH. MAINTAIN WEAPONS ORIENTED FUND. RSCH. PROG. RELATED TO ARMY NEEDS. CONDUCT EXPLORATORY DEV. EFFORTS TO SOLVE MILITARY PROBLEMS AND EVAL. SOLUTION FEASIBILITY.

...CURRENT IMPORTANT PROGRAMS

ANTI-ARMOR WARHEADS AND KINITIC ENERGY PENETRATORS.
BALLISTIC PROTECTION TECHNOLOGY FOR US MATERIEL.
LIQUID PROPULSION TECHNOLOGY GUNS.
VULNERABILITY ANALYSIS/VULNERABILITY REDUCTION US/THREAT MATERIEL.
MUNITION SURVIVABILITY ANALYSES AND ENHANCEMENT.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

LASER DIAGNOSTIC FACILITY FOR PROPELLANT/FLAME ANALYSIS; COMPUTED TOMOGRAPHY FOR BALLISTIC EVENTS;PROPELLANT FRACTURE MECHANICS ANALYSIS FACILITY;INSTRUMENTED INDOOR AERODYNAMIC FLIGHT RANGES FOR PROJECTILES UP TO 8INCHES;THREE DEGREE-OF-FREEDOM FLIGHT SIMULATOR FOR SHELL UP TO 155MM;EXPLOSIVE MECHANICS TEST FACILITY;HIGH EXPLOSIVE CASTING AND PRESSING; HIGH ALTITUDE BLAST SPHERE; THERMAL/BLAST SHOCK TUBE TO SIMULATE NUCLEAR EFFECTS; ADVANCED HIGH KINITIC ENERGY LAUNCH SYSTEM FOR ANTI-ARMOR RESEARCH;ANECHOIC CHAMBER FOR MM WAVE RADAR, SENSOR, AND SCALE MODEL SIGNATURE RESEARCH;ION BEAM ACCELERATOR; FIELD TEST FAC. FOR WARHEAD,PENETRATOR,EXPLOSIVE AND ARMOR RESCH; HIGH SPEED AND SPARK PHOTOGRAPHY;X-RAY CINERADIOGRAPHY;COMPUTER AIDED DESIGN ENG.; AND CENTRAL SITE AND MINI COMPUTERS WITH 650 REMOTE INTERACTIVE TERMINALS.

INSTALLATION: BELVOIR R & D CENTER FT.BELVOIR,VA. ✓

CDR. COL. DENNIS B. BULGER TECH. DIR. MR.T. W. LOVELACE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 106.095 | 134.865 |
| TOTAL PROCUREMENT | 183.279 | 137.217 |
| TOTAL O&M | 16.785 | 14.399 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 306.159 | 285.981 |
| TOTAL INHOUSE | 49.854 | 48.597 |
| TOTAL INHOUSE RDT&E | 39.399 | 39.860 |
| ANNUAL OPERATING COST | 18.653 | 19.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 71 | 1 | 66 | 5 |
| CIVILIAN | 1178 | 27 | 399 | 779 |
| TOTAL | 1249 | 28 | 465 | 784 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1052 | 353.082 | 186.816 | 268.237 | 808.135 | 18.871 | 87.028 |

...MISSION

PROVIDE THE ARMY WITH NEW, IMPROVED COMBAT SUPPORT, COMBAT SERVICE SUPPORT EQMT THROUGH RESEARCH, DEVELOPMENT, ENGINEERING, INITIAL ACQUISTION, AND SUBSEQUENT ACQUISITION SUPPORT IN MOBILITY/COUNTER-MOBILITY, ENERGY, SURVIVABILITY, AND LOGISTICS EQMT SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

COUNTERMINE/COUNTEROBSTACLE EQMT
FUELS, LUBES DEV
TACTICAL DECEPTION DEVICES
WATER SUPPLY EQMT
PETROLEUM DISTRIBUTION SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

ACCOMPLISH RSCH, DEV, ACQUISITION OF MAT FOR COUNTEROBSTACLE, BARRIERS, FIELD FORTIFICATION TACTICAL DECEPTION CAMO,TUNNEL DETECTION, PHYS SECURITY, FUELS, LUBES, FUEL HNDLG EQMT, ELEC POWER GENERATION, TOPOGRAPHY, WATER SUPPLY, MAT HNDLG, MARINE, RAIL TRANSPORT, BRIDGING, CONSTRUCTION EQMT. FACILITIES INCLUDE MINE FIELD TEST LANES, SENSOR TEST AREA, RDO FREQ ANECHOIC CHAMBER, FIRE SUPPRESSION CHAMBER, BRIDGE TEST HANGER, MOBILE STRESS ANAYLIS VAN, TRUCK STABILITY TILT TABLE, VEHICLE TEST TRACKS, SHOCK AND VIBRATION DYNAMICS SIM, ENVIRONMENTAL SIMULATION, RAIL IMPACT TEST FACILITY, MATERIALS RESEARCH LABORATORY, STILL AND MOTION PICTURE SUPPORT, RESEARCH AND DEVELOPMENT MODEL FABRICATION SHOPS.

INSTALLATION: CHEMICAL R&D CENTER ABERDEEN PROV. GR.,M

CDR. BG. HOWARD C. WHITTAKER DEP. DIR. DR. B. RICHARDSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 102.490 | 117.029 |
| TOTAL PROCUREMENT | 24.070 | 63.300 |
| TOTAL O&M | 9.700 | 8.015 |
| TOTAL OTHER | 1.950 | 2.000 |
| TOTAL ANNUAL LAB | 138.210 | 190.344 |
| | | |
| TOTAL INHOUSE | 79.665 | 76.655 |
| TOTAL INHOUSE RDT&E | 57.920 | 55.940 |
| ANNUAL OPERATING COST | 10.321 | 12.671 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 95 | 6 | 39 | 56 |
| CIVILIAN | 903 | 71 | 596 | 307 |
| TOTAL | 998 | 77 | 635 | 363 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1750 | 434.009 | 211.091 | 549.086 | 1194.186 | 21.815 | 32.656 |

...MISSION

A RSCH, DEV AND ENGR LAB PROVIDING US FORCES WITH CAPABILITY TO OPERATE ON A CML/BIOL BATTLEFIELD AND DETER CML ATTACK. PROVIDE LIFE CYCLE ENGR FOR CML WEAPONS AND CML/BIOL DEFENSE. ACT AS DOD LEAD LAB FOR CML DEF/DETERRENCE. CONDUCT SMOKE/OBSCURANT TECH BASE. COORDINATE INTL PROGRAMS.

...CURRENT IMPORTANT PROGRAMS

CB RECONAISSANCE, DETECTION AND IDENTIFICATION
INDIVIDUAL/COLLECTIVE PROTECTION
CB DECONTAMINATION AND CONTAMINATION AVOIDANCE
SMOKE OBSCURANT SYSTEMS
CHEMICAL DETERRENT SYSTEMS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

BASIC RESEARCH; SMOKE/OBSCURANT SYSTEMS; CHEMISTRY AND EFFECTS OF THREAT AGENTS; ANALYSIS AND INTEGRATION OF CML DEF SYSTEMS; RECONNAISSANCE, DETECTION, AND IDENTIFICATION; INDIVIDUAL PROTECTION; COLLECTIVE PROT; DECONTAMINATION AND CONTAMINATION AVOIDANCE; TRAINING SYSTEMS; TOXIN DEFENSE; CHEMICAL DETERRENT SYSTEMS.

MAJOR EQUIPMENT IS CONTAINED IN A COMPLEX OF ENGR/LAB AREAS. INCLUDES CML PILOT PLANTS, AEROSOL CHAMBER, MUNITION FILLING FACILITY, PRODUCTION AND FACILITY DESIGN, CHAMBER FOR STUDIES ON SPEECH TRANSMISSION, SIMULANT AGENT CHALLENGE TEST CHAMBER, RUBBER/ELASTOMER MOLD FACILITY, SPECIALIZED CHEMICAL AGENT LAB, PYROTECHNIC MIXING, LOADING, HANDLING FACILITY, COMPUTERMAN, INDOOR BALLISTIC RANGE, SUBSONIC-SUPERSONIC, TRANSONIC WIND TUNNEL.

INSTALLATION: COLD REGIONS R&E LABORATORY HANOVER,N.H.

CDR. DIR. COL. M. F. ROTH TECH. DIR. DR. LLOYD BRESLAU

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 10.888 | 12.068 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.475 | 1.037 |
| TOTAL OTHER | 8.267 | 9.443 |
| TOTAL ANNUAL LAB | 19.630 | 22.548 |
| TOTAL INHOUSE | 14.280 | 10.758 |
| TOTAL INHOUSE RDT&E | 6.968 | 7.724 |
| ANNUAL OPERATING COST | 3.839 | 4.256 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 15 | 0 | 3 | 12 |
| CIVILIAN | 263 | 34 | 125 | 138 |
| TOTAL | 278 | 34 | 128 | 150 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 20 | 80.787 | 30.027 | 133.024 | 243.838 | 8.835 | 9.618 |

...MISSION

AS THE ARMY LABORATORY FOR SCIENCE AND TECHNOLOGY IN COLD REGIONS, THE COLD REGIONS RESEARCH & ENGINEERING LABORATORY CONDUCTS AND COORDINATES RESEARCH APPLICABLE TO THE ARMY'S NEEDS WHERE WINTER WEATHER AND COLD PRESENT A SEVERE PROBLEM. MANAGE ARMY COLD REGIONS INFORMATION CENTER

...CURRENT IMPORTANT PROGRAMS

WINTER COMBAT OPERATIONS TECHNOLOGY
IMPACT OF WINTER ENVIRONMENT ON NEW WEAPON SYSTEMS AND OTHER MATERIEL
FACILITIES CONST, OPERATION, & REPAIR IN TEMP & ARCTIC COLD CONDITIONS
IMPROVE WINTER NAVIGATION
DEVELOP ENVIRONMENTAL REMOTE SENSING APPLICATIONS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THE MAIN LABORATORY AT USACRREL CONTAINS 24 COLD LABS (WHICH CAN BE OPERATED TO -58 F), SPECIAL TESTING APPARATUS FOR FROZEN MATERIALS, AN ICE ENGINEERING FACILITY FOR LARGE MODELING EXPERIMENTS WITH ICE, A CHEMISTRY LAB, AN ELECTRON MICROSCOPE LAB, A SOILS PROCESSING LAB, A PAVEMENT TEST FACILITY FOR TESTING UNDER FREEZING/THAWING CONDITIONS, A WASTEWATER TREATMENT RESEARCH FACILITY, A COMPUTER FACILITY, A MASS SPECTROMETER, A GAS CHROMATOGRAPH, AND A SMALL LASER FACILITY. THE ALASKA PROJECTS OFFICE AT FAIRBANKS CONDUCTS RESEARCH AND PROVIDES LOGISTICS SUPPORT FOR OTHER RESEARCH. USACRREL'S MILITARY AND CIVILIAN PERSONNEL HAVE EXPERTISE COVERING A WIDE RANGE OF SCIENTIFIC AND ENGINEERING DISCIPLINES RELATED TO COLD REGIONS RESEARCH. NEW FACILITIES SCHEDULED FOR CONSTRUCTION INCLUDE A FROST EFFECTS RESEARCH FACILITY.

INSTALLATION: COLD REGIONS TEST CENTER APO SEATTLE.WA.

CDR. COL. JESSE H. DENTON TECH. ADV. MR. WILLIAM J. HASLEM

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 7.035 | 6.159 |
| TOTAL PROCUREMENT | 0.090 | 0.080 |
| TOTAL O&M | 0.006 | 0.000 |
| TOTAL OTHER | 5.303 | 5.462 |
| TOTAL ANNUAL LAB | 12.434 | 11.701 |
| TOTAL INHOUSE | 12.434 | 11.701 |
| TOTAL INHOUSE RDT&E | 7.035 | 6.159 |
| ANNUAL OPERATING COST | 7.305 | 6.159 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 263 | 0 | 31 | 232 |
| CIVILIAN | 22 | 0 | 11 | 11 |
| TOTAL | 285 | 0 | 42 | 243 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 647155 | 0.000 | 18.205 | 236.033 | 254.238 | 10.836 | 9.283 |

...MISSION

PLAN,CONDUCT,AND REPORT THE RESULTS OF COLD REGIONS,MOUNTAIN AND NORTHERN ENVIRONMENTAL PHASES OF DEVELOPMENT AND OTHER TEST; REVIEW PLANS AND MONITOR DEVELOPMENT TESTING IAW INTEGRATED TESTING CYCLE POLICIES. PROVIDE ADVICE AND GUIDANCE TO GOVT AGENCIES AND PRIVATE IND.

...CURRENT IMPORTANT PROGRAMS

M1E1 ABRAMS TANK
AN-TPQ 36&37 RADAR
LIGHT ARMOR VEHICLE (LAV)
SMALL UNIT SUPPORT VEHICLE (SUSV)
MODULAR PACK MINE SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

FACILITY CAN ACCOMODATE A WIDE VARIETY AND LARGE NO TEST AT ANY ONE TIME.SEVERAL VEH TEST COURSES AND EXTENSIVE CROSS COUNTRY TERRAIN RANGES ARE AVAILABLE.500,000 ACRE ISOLATED IMPACT AREA,50KM MAX UNOBSERVED RANGE.LARGE RESTRICTED AIRSPACE WITH UNRESTRICTED FIRING TO 108000 FT ORDINATE.COORD WITH FAA CAN EFFECT UNRESTRICTED ORDINATE.1ST,2ND,OR 3RD ORDER SURVEY POINTS.GOOD SECONDARY ROADS.PHONE/NON-TAC RADIO AT ALL RANGES AND TEST SITES. AUTODIN,FACSIMILE,TELETYPE,PHOTO LAB AND MAINT FOR MAJORITY OF EQUIP INCL ACFT,DS/GS CALIBRATION,LIMITED ENGR SUPPORT. ARMY AVN AND USAF ACFT CAN BE ARRANGED.METEROLOGICAL SPT AVAIL.INST FOR MOST ITEMS AVAIL,CAN OBAIN OTHER INSTRUMENTS.MOVING TARGET SYSTEM,EOD, STATISTICAL,MAINT EVALUATION,AND HUMAN FACTORS CAPABILITIES AVAILABLE COMPUTER FACILITY AVAILABLE. TEMPERATURES TO -50 F COMMON.

INSTALLATION: COMBAT SURVEILLANCE & TGT ACQUISITION LAB FT.MONMOUTH,N.J.

DIR. COL JOHN MARKHAM DEPUTY DIR. MR. THOMAS DANIELS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 24.344 | 33.941 |
| TOTAL PROCUREMENT | 11.451 | 69.155 |
| TOTAL O&M | 2.016 | 1.814 |
| TOTAL OTHER | 0.160 | 0.270 |
| TOTAL ANNUAL LAB | 37.971 | 105.180 |
| | | |
| TOTAL INHOUSE | 9.567 | 12.473 |
| TOTAL INHOUSE RDT&E | 7.816 | 7.912 |
| ANNUAL OPERATING COST | 2.220 | 2.440 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 12 | 0 | 8 | 4 |
| CIVILIAN | 167 | 3 | 98 | 69 |
| TOTAL | 179 | 3 | 106 | 73 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 35 | 52.324 | 6.139 | 10.589 | 69.052 | 0.680 | 7.050 |

...MISSION
RADIOLOGICAL TEST SHIELD & SOURCES
RADAR TEST RANGE - 2000 FT & 50 FT PLATFORM
ANACHOIC CHAMBER FOR RADAR PATTERN TEST
TARGET TURN-TABLE FOR RADAR,OPTICAL SIGNATURE STUDIES

...CURRENT IMPORTANT PROGRAMS
WIDE AREA AERIAL RADAR SURVEILLANCE & TARGET LOCATION SYSTEMS
ACOUSTIC & RADAR TECHNOLOGY TO LOCATE ENEMY WEAPONS
LOW PROBABILITY OF ENEMY DETECTION RADARS
AERIAL & GROUND RADIOLOGICAL SURVEY SYSTEMS
NON COOPERATIVE & COOPERATIVE IFF SYSTEMS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
NON COOPERATIVE TARGET RECOGNITION TEST BED

INSTALLATION: COMMUNICATIONS - ELECTRONICS R & D CENTER FT MONMOUTH,N.J.

CDR. MG LAWRENCE F. SKIBBIE TECH. DIR. MR. THEODORE PFEIFFER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 110.497 | 0.000 |
| TOTAL PROCUREMENT | 29.279 | 0.000 |
| TOTAL O&M | 8.732 | 0.000 |
| TOTAL OTHER | 2.943 | 0.000 |
| TOTAL ANNUAL LAB | 151.451 | 0.000 |
| TOTAL INHOUSE | 47.690 | 0.000 |
| TOTAL INHOUSE RDT&E | 35.908 | 0.000 |
| ANNUAL OPERATING COST | 1.762 | 0.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 73 | 0 | 22 | 51 |
| CIVILIAN | 551 | 14 | 362 | 189 |
| TOTAL | 624 | 14 | 384 | 240 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 59.031 | 79.011 | 11.200 | 149.242 | 0.000 | 22.500 |

...MISSION

CONDUCT RSCH, EXPL, ADV & ENGR DEV OF COMM. EQUIP & SYSTEMS, MILITARY COMPUTER EQUIP & SYSTEMS, & COMPUTER SOFTWARE. CONDUCT SYSTEM ENGR FOR TACTICAL COMMAND, CONTROL& COMM. SYSTEM DESIGN. PROVIDE FOR PROD. DIST. & DEL. OF DOCTRINAL, INSTRUCTIONAL & TECHNICAL MATERIALS.

...CURRENT IMPORTANT PROGRAMS

DISTRIBUTED COMMAND CONTROL & COMMUNICATION (DC3)
PACKET RADIO TECHNOLOGY
MILITARY COMPUTER FAMILY
BATTLEFIELD SPECTRUM MANAGEMENT
ELECTRONIC INFORMATION DELIVERY SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

COMMUNICATIONS SYSTEM DESIGN CENTER
ACOUSTIC RESEARCH LABORATORY
TELEPROCESSING DESIGN CENTER
SYSTEMS VALIDATION FACILITY
EXPERIMENTAL DISTRIBUTED PROCESSING FACILITY
SOFTWARE DEVELOPMENT SUPPORT SYSTEM
TACTICAL DATA BASE MANAGEMENT SYSTEM
CENSEI INTEROPERABILITY TEST CENTER
CENSEI SYSTEM SIMULATION FACILITY

IV INSTALLATION: CONSTRUCTION ENGINEERING RESEARCH LAB CHAMPAIGN, IL.

CDR. DIR. COL. PAUL J. THEUER TECH. DIR. DR. L. R. SHAFFER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 19.445 | 20.821 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 2.398 | 3.050 |
| TOTAL OTHER | 2.155 | 2.783 |
| TOTAL ANNUAL LAB | 23.998 | 26.654 |
| | | |
| TOTAL INHOUSE | 15.631 | 18.428 |
| TOTAL INHOUSE RDT&E | 12.506 | 14.103 |
| ANNUAL OPERATING COST | 4.000 | 4.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 11 | 0 | 11 | 0 |
| CIVILIAN | 208 | 29 | 141 | 67 |
| TOTAL | 219 | 29 | 152 | 67 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 30 | 56.785 | 34.750 | 20.019 | 111.554 | 6.500 | 6.000 |

...MISSION

PLAN AND EXECUTE RESEARCH TO OBTAIN THE BEST COMBINATION OF ENGINEERING DESIGN, CONSTRUCTION, OPERATIONS AND MAINTENANCE TO PROVIDE FACILITIES FOR THE MILITARY ESTABLISHMENT AND OTHER AGENCIES AT LEAST COST AND TO DISSEMINATE THE RESEARCH RESULTS.

...CURRENT IMPORTANT PROGRAMS

DEV ENERGY CONS TECH/PROC FOR MIL INSTLS
DEV COMPUTER AIDED SYSTEMS FOR PLANNING AND DESIGN
DEV IMPROVED SYSTEMS FOR RPMA OF MIL FACILITIES
DEV SYSTEMS FOR ENVIRONMENTAL QUALITY MGMT
ADAPT ALTERNATE FUELS TECH FOR MIL FACILITIES

...FUNCTIONS/EQUIPMENT/CAPABILITIES

CONTROLLED ENV CHAMBERS; ION PLATING EQMT; 1000000-PD CLOSED-LOOP MTRL TEST SYS; SCANNING ELECTRON MICROSCOPE; SEMI-AUTO WELDING EQMT; BI-AXIAL SHOCK TEST MACHINE; NON-DES TESTING FAC; VACUUM INDUCTION FURNACES; METALLOGRAPHIC SAMPLE PREP; METALLOGRAPH X-RAY DIFFRACTION AND VACUUM SPECTROSCOPY SYS; DYNAMIC TENSION ANALYSIS SYS; DIGITAL RECORDING ANAL EQMT; AND HVAC TEST FAL. CAPABILITIES INCLUDE SYSTS BUILDING METHODS AND TECHS; COMPUTER-BASED DESIGN AND CONST MGMT TECHS; ENERGY SYSTS DESIGN; ENERGY CONSERVATION AND ALTERNATE FUELS; HARDENED FACS ANALYSIS; ENV QUALITY MGMT; POLLUTION CONTROL ABATEMENT; MIL HOUSING SYSTS; TRAINING-AREA MAINTENANCE AND MGMT; MOBILIZATION FACS; QUALITY OF LIFE AND ARCHITECTURAL RESEARCH; AND ELECTROMAGNETIC PULSE INTERFERENCE RESEARCH.

INSTALLATION: ELECTRONIC WARFARE LABORATORY FT.MONMOUTH,N.J.

DIR. MR. MAX ADLER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 92.926 | 117.116 |
| TOTAL PROCUREMENT | 65.011 | 72.874 |
| TOTAL O&M | 12.500 | 4.420 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 170.437 | 193.910 |
| TOTAL INHOUSE | 31.049 | 37.399 |
| TOTAL INHOUSE RDT&E | 22.855 | 82.803 |
| ANNUAL OPERATING COST | 3.500 | 3.700 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 84 | 1 | 75 | 9 |
| CIVILIAN | 403 | 6 | 206 | 197 |
| TOTAL | 487 | 7 | 281 | 206 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 325 | 163.877 | 26.617 | 37.314 | 227.808 | 6.078 | 55.580 |

...MISSION

RESEARCH, DEVELOPMENT, INITIAL ACQUISITION, AND FIRST FIELDING OF NON-COMMUNICATIONS AND SELECTED COMMUNICATIONS EQUIPMENT. DEVELOPMENT OF ELECTRONIC COUNTER-COUNTERMEASURES RECOMMENDATIONS AND TECHNIQUES.

...CURRENT IMPORTANT PROGRAMS

PROD OF SIGINT EQPT, E.G.,QUICK LOOK,GUARDRAIL,TEAMPACK
DEVELOP ECM AND WARNING EQPT FOR SELF PROTECTION OF COMBAT VEHICLE.
EW VULN INVESTIGATIONS OF MISSILE SYS E.G., PATRIOT, ROLAND AND DIVAD.
DEVELOPMENT, INITIAL ACQUISIT, FIRST FLDING EW AND RELATED INTL MATERIAL
DEV EW SYS TO ENHANCE EFFECT AND SURVIV AIR DEFENSE ART UNITS E.G.ADEWS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

ELECTRONIC INTELLIGENCE (ELINT) ANECHOIC CHAMBER.
SIMULATED ECM TECNIQUES EVALUATOR (SECTER).
ELECTRO-OPTICAL COUNTERMEASURES (EOCM) SIMULATOR.
EOCCM SIMULATOR.
INFRARED MEASUREMENTS AND DATA REDUCTION FACILITY.
BIG CROW.
MOBILE ELECTRONIC WARFARE VULNERABILITY/ECCM TEST VAN.
EARLE WAYSIDE TEST SITE.
GRAPHICS ANALYSIS SYSTEM (OMEGA).
SIMULATED ELECTRONIC COUNTER-COUNTERMEASURES TECHNIQUE EVALUATOR.
ULTRAVIOLET/INFRARED (UV/1R) SCENE GENERATOR.

/ INSTALLATION: ELECTRONICS TECHNOLOGY AND DEVICES LAB FT.MONMOUTH,N.J.

DIR. DR. C. G. THORNTON TECH. DIR. MR. ROBERT G. LAUTTMAN

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 68.825 | 80.970 |
| TOTAL PROCUREMENT | 5.575 | 1.898 |
| TOTAL O&M | 0.785 | 0.784 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 74.685 | 83.652 |
| TOTAL INHOUSE | 19.962 | 22.735 |
| TOTAL INHOUSE RDT&E | 17.682 | 20.341 |
| ANNUAL OPERATING COST | 5.287 | 7.069 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 1 | 0 | 1 | 0 |
| CIVILIAN | 291 | 40 | 184 | 107 |
| TOTAL | 292 | 40 | 185 | 107 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 81.909 | 5.537 | 4.467 | 91.913 | 0.000 | 14.000 |

...MISSION

TO DEV ESSENTL BASE IN ELECTRNCS TECH & DEVICES CONSISTNT WITH NEXT GENRATN ARMY SYS OPERATNL REQMTS. TO THIS END, AN ELECTRONCS-ORIENTED APPL R&D PROG IS PURSUED, FOCUSING ON CRITICL BARRIER DEVICES & MATRL PROBLMS THAT INHIBIT UPGRADING EXISTING & DEV NEW ARMY SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

MMW DEVICES & PULSERS FOR TARGET LOC & IDENT THRU SMOKE & FOG
SIG PROC DEVICES TO PERMIT NONAMMABLE COMMO & DEEP BATTLEFLD ASSMNT
PULSE POWER SOURCES FOR DIRECT BEAM WEAPONS & LASER DESIGNATORS
LIGHTWT, EFFICIENT PORTABLE POWER FOR SESIGNATORS, NV & C/E SYSTEMS
INTELLIGENT, INTERACTIVE TERMINALS & DISPLAY DEVICES FOR TACTICALS OPS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

ADVANCED RESRCH FACIL'S SUCH AS MBE SYSTEM, LEBES E-BEAM LITHOGRAPHIC SYSTEM. ISS/SIMS, CADDA & AUGER ELECTRON SPECTROSCOPY ARE AVAIL FOR PERFORMING ON PREP, PROPERTIES & CONTRL OF ELEC MATERIALS & ON ELEC PARTS, DEVICES IC'S & ASSEMBLIES. AREAS OF LAB EXPERTISE INCL: COMPL DESIGN, FABRIC & TESTING OF IC'S, HYBRID CIRCUIT ASSEMBLIES, SEMICONDUCTOR DEVICES & CIRCUITS, SURFACE ACOUSTIC WAVE DEVICES, ELECTRON TUBES, DISPLAY DEVICES, PRIMARY, SECONDARY & SPEC PURPOSE PWR SOURCES, ELECTROCHEM RESEARCH CHARACTERIZATION OF ELEC MATERIALS, QUICK TURNAROUND CUSTOMIZED & FABRIC OF LSI ARRAYS ARE AVAIL TO CIRCUIT & SYSTEM DESIGNERS IN OTHER ARMY LABS. LAB ALSO PROVISES ARMY CUSTOMERS WITH EXPRT SERVICES INCL DIRECT R&D DEV, SUPPORT, CONSULTATION & DIRECT PARTICIPATION IN SYSTEM DEV.

INSTALLATION: ENGINEER TOPOGRAPHIC LABORATORIES FT.BELVOIR,VA.

CDR. COL. EDWARD K. WINTZ TECH. DIR. MR. WALTER E. BOGE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 42.883 | 49.576 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 2.739 | 2.580 |
| TOTAL OTHER | 0.261 | 0.270 |
| TOTAL ANNUAL LAB | 45.883 | 52.426 |
| TOTAL INHOUSE | 12.990 | 14.426 |
| TOTAL INHOUSE RDT&E | 10.983 | 12.242 |
| ANNUAL OPERATING COST | 8.575 | 8.700 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 14 | 1 | 8 | 6 |
| CIVILIAN | 286 | 18 | 169 | 117 |
| TOTAL | 300 | 19 | 177 | 123 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 33 | 90.722 | 7.000 | 13.300 | 111.022 | 6.000 | 12.448 |

...MISSION

RESEARCH AND DEVELOPMENT IN TOPOGRAPHIC SCIENCES, MAPPING, POINT POSITIONING, AND MILITARY GEOGRAPHIC INFORMATION, OPERATIONAL SUPPORT, TERRAIN ANALYSIS, AND SCIENTIFIC/ADVISORY SERVICES, REMOTE SENSING, COMPUTER TECHNOLOGY, AND ENVIRONMENTAL EFFECTS DATA.

...CURRENT IMPORTANT PROGRAMS

SUPPORT TO THE ARMY SPACE PROGRAM
DIGITAL TOPOGRAPHIC SUPPORT SYSTEM
MODULAR AZIMUTH AND POSITIONING SYSTEM
QUICK RESPONSE MULTICOLOR PRINTER
ARTIFICIAL INTELLIGENCE/ROBOTICS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

FACILITIES INCLUDE A CARTOGRAPHIC LABORATORY TO STUDY THE PROBLEMS ASSOCIATED WITH HANDLING DIGITAL CARTOGRAPHIC DATA, A DIGITAL-IMAGE PROCESSING LABORATORY TO STUDY THE MANIPULATION AND ENHANCEMENT OF TERRAIN IMAGERY FOR OBTAINING MAPPING AND GEOGRAPHIC DATA, COMPUTER ASSISTED PHOTO-INTERPRETATION STATION FOR EXPERIMENTAL EXTRACION OF TERRAIN FEATURES, AND AN ARTIFICIAL INTELLIGENCE TEST BED FOR USE IN TERRAIN FEATURE EXTRACTION AND EXPLOITATION EXPERIMENTS. COMPUTATIONAL EQUIPMENT INCLUDES THE CDC CYBER 170/730, GOODYEAR STARAN S-1000, DEC PDP 1150 AND PDP 1170 AND DEC VAX MODELS 780 AND 750. OTHER SPECIALIZED EQUIPMENT INCLUDE A COMTAL, PDS DIGITAL AUTOMATED MICRODENSITOMETERS, AND PRECISION MENSURATION EQUIPMENT.

INSTALLATION: ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG,MS.

CDR./DIR. COL TILFORD C. CREEL TECH. DIR. MR. F. R. BROWN

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 29.329 | 33.740 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.848 | 1.400 |
| TOTAL OTHER | 61.573 | 63.560 |
| TOTAL ANNUAL LAB | 91.750 | 98.700 |
| | | |
| TOTAL INHOUSE | 77.073 | 82.270 |
| TOTAL INHOUSE RDT&E | 25.647 | 28.340 |
| ANNUAL OPERATING COST | 7.880 | 9.900 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 23 | 1 | 23 | 0 |
| CIVILIAN | 1538 | 101 | 590 | 948 |
| TOTAL | 1561 | 102 | 613 | 948 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 951 | 1739.308 | 334.925 | 168.824 | 2243.057 | 31.259 | 44.996 |

...MISSION

MIL.&CIV FUNDED RSCH,DEV&INVES IN HYD,ECOLOGY, COASTAL ENGR. PAVEMENTS, SOIL,CONC.,EXPLO WPN EFF,EXPLO EXCAVATION,VEH MOBILITY & ENVIRONMENTAL ASPECTS OF MIL OPERATIONS. OPERATE TECH LIBRARY&GOVERNMENT CEMENT POZZOLAN TEST PROGRAM. SERVES CE,DARCOM,DNA,AF,NAVY,DOE,EPA & OTHER AGENCIES.

...CURRENT IMPORTANT PROGRAMS

HYD&MATH MODELING TO SOLVE RIVER,TIDAL,WIND-WAVE,ECOLOGICAL&STRUC.PROBS.
RSCH ON VEH MOBILITY,REMOTE SENSING,ENVIR IMPACT,&EARTHQUAKE DESGN CRIT.
NUC&HE RSCH TO DEV CRIT FOR DESGN OF PROTECT.STRUC,BARRIERS&EXCAVATIONS.
RSCH&DEV OF NEW&IMPROVED ENG DESGN CRIT FOR ROADS,STOR AREAS,&AIRFIELDS.
RSCH&DEV OF CEMENTITIOUS MATLS AND RSCH OF MASS AND STRUCTURAL CONCRETE.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

CAPABLE OF PERF GEN INVEST IN FLD OF HYD,SOIL MECH,CONCRETE,MOBILITY OF MIL VEH,EXPLO EFF,ECOLOGY,COASTAL ENGINEERING & DEV OF STRUCT & PAVEMENT DESIGN CRIT BY BASIC & APP RSCH; CAPABLE OF DEV METHODS&TECHNOLOGY FOR TESTING MATLS&EQUIP IN SUPPORT OF THE CE MISSION. WES RESERVATION CONTAINS BLDGS,TEST SITES,SPECIAL AND OTHER PLANT SUPPORT EQUIP, TEST SITES &FAC FOR SPECIAL PURPOSES ARE MAINT IN OTHER AREAS ON PERM./TEMP BASIS. FAC. INCL. FLUMES OF DIFF TYPES&SIZES, WAVE&TIDE GENERATORS. WELL EQUIPPED SOILS, CONC, CHEM, CALIB, ELEC&TEMP CONTROLLED ENVIRONMENTAL AND LYMNOLOGICAL LABS, X-RAY DIFFRACTION & SPECTROSCOPY EQUIP, SMALL AND LARGE BLAST LOAD GENERATORS,200K DYNAMIC LOADER, MOBILITY RSCH FAC, SINGLE AND MULTIPLE WHEEL LOAD CARTS,SURFACE BLAST EFF FAC,HIGH&LOW FREQ VIBRATORS, ELECTRONBEAM MICROSCOPE, LARGE SCALE COMPUTER FAC AND TECH LIBRARY.

INSTALLATION: FIRE CONTROL & SMALL CAL. WPNS SYSTS LAB DOVER,N.J.

CDR. COL R. R. ROSS DEP. DIR. MR. D. G. ADAMS

| PROGRAM | PROGRAM DATA BY FISCAL YEAR (MILLION $) 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 40.830 | 41.000 |
| TOTAL PROCUREMENT | 52.756 | 59.600 |
| TOTAL O&M | 10.505 | 13.200 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 104.091 | 113.800 |
| TOTAL INHOUSE | 83.676 | 89.600 |
| TOTAL INHOUSE RDT&E | 27.812 | 28.000 |
| ANNUAL OPERATING COST | 21.025 | 21.750 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 14 | 0 | 14 | 0 |
| CIVILIAN | 650 | 28 | 415 | 235 |
| TOTAL | 664 | 28 | 429 | 235 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) LAB | ADMIN | OTHER | TOTAL | COST (MILLION $) REAL PROP | EQUIP |
|---|---|---|---|---|---|---|
| 6 | 167.247 | 103.974 | 4.576 | 275.797 | 8.305 | 26.060 |

...MISSION
ACCOMPLISH EXPLORATORY RESEARCH,ADVANCED AND ENGINEERING DEVELOPMENT LIFE CYCLE TECH RESPONSIBILITY FOR FIRE CONTROL AND ALL WEAPON SYSTEMS, AMMUNITION, AUXILIARY ITEMS THROUGH 40MM CAL.FIRE CONTROL INCLUDES ALL COMBAT VEHICLES, FIELD ARTILLERY, HELICOPTERS, AIR DEFENSE AND INFANTRY

...CURRENT IMPORTANT PROGRAMS
JOINT SERVICES SMALL ARMS PROGRAM JSSAP
LONG ROD PENETRATOR
RSCH SM CAL ARM
SGT YORK AIR DEFENSE GUN SYSTEM FORMERLY DIVADS SUPPORT
RSCH SM CAL AND FC TECH

...FUNCTIONS/EQUIPMENT/CAPABILITIES
LABORATORY CONDUCTS RESEARCH/EXPLORATORY,ADVANCED AND ENGINEERING DEVELOPMENT IN SMALL CALIBER WEAPON SYSTEMS AND FIRE CONTROL SYSTEMS.IT MAINTAINS TEST BED FACILITIES TO EVALUATE SYSTEMS IN AREAS OF FIRE CONTROL, AIR DEFENSE AND COMBAT VEHICLES.LAB HAS CAPABILITY FOR DESIGN AND EVALUATION OF OPTICAL,ELECTRO-OPTICAL AND ELECTROMAGNETIC SYSTEMS,SIGNTING DEVICES, DIGITAL AND ANALOG SIGNAL PROCESSORS,GUN/TURRET STABILIZATION AND CONTROL SYSTEMS, SMALL CALIBER WEAPONS INCLUDING AUTOMATIC CANNONS, WEAPON MECHANISMS,MOUNTS,PROJECTILES,PENETRATORS,SHAPED CHARGE LINERS, PROPELLANTS, PRIMERS,CARTRIDGE CASES,METAL AND PLASTIC MATERIALS AND ADHESIVES,AND MANUFACTURING TECHNOLOGY.JOINT SERVICE SMALL ARMS PROGRAM HAS RESPONSIBILITY FOR ALL SMALL ARMS CONVENTIONAL AND SPECIAL WEAPONS SYSTEMS FOR ALL USERS.

INSTALLATION: HUMAN ENGINEERING LABORATORY ABERDEEN PRO.GR.,MD.

DIR. DR. JOHN D. WEISZ

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 14.977 | 15.008 |
| TOTAL PROCUREMENT | 0.428 | 0.400 |
| TOTAL O&M | 2.760 | 1.250 |
| TOTAL OTHER | 0.564 | 0.550 |
| TOTAL ANNUAL LAB | 18.729 | 17.208 |
| TOTAL INHOUSE | 14.378 | 14.186 |
| TOTAL INHOUSE RDT&E | 10.998 | 12.186 |
| ANNUAL OPERATING COST | 1.639 | 2.148 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 85 | 1 | 10 | 25 |
| CIVILIAN | 179 | 18 | 117 | 62 |
| TOTAL | 214 | 19 | 127 | 87 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 72 | 111.524 | 7.056 | 21.400 | 139.980 | 8.112 | 8.507 |

...MISSION

CONDUCTS FUNDAMENTAL AND APPLIED RESEARCH IN HUMAN FACTORS ENGINEERING PROVIDES DIRECT DESIGN SUPPORT TO ALL MATERIEL DEVELOPMENT PROGRAMS SPONSORED BY DARCOM. NINETEEN DETACHMENTS AND/OR LIAISON REPRESENTATIVES HAVE BEEN ESTABLISHED AT DARCOM COMMANDS, CRTC AND TRADOC CTRS/SCHOOLS.

...CURRENT IMPORTANT PROGRAMS

AUTOMATION/ARTIFICIAL INTELLIGENCE/ROBOTICS
INDIVIDUAL SOLDIER PROTECTIVE CLOTHING/EQUIPMENT
BATTLEFIELD ROBOTIC AMMUNITION SUPPLY SYSTEM
COMMAND CONTROL COMMUNICATIONS INTERFACE
FIRE CONTROL RESEARCH.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

COMMAND POST EXERCISE FACILITY
ACE COMPUTER FACILITY
FIRE CONTROL RESEARCH FACILITY
DATA ACQUISITION AND BIOTELEMETRY SYSTEM
GAT 2M HELICOPTER SIMULATOR
ACOUSTICAL AND ANECHOIC CHAMBER REVERBERANT ROOM
HELFAST LOGISTICS TESTING FACILITIES
EYE MOVEMENT MEASURING DEVICE
SMALL ARMS TEST FIRING RANGE
WOOD AND METAL WORKING TEST SUPPORT CAPABILITY
HUMAN FACTORS DATA BANK
COMMAND CONTROL SIMULATOR SYSTEM

INSTALLATION: INSTITUTE OF DENTAL RESEARCH WASHINGTON,D.C.

CDR. COL. THOMAS P. SWEENEY DEP. FOR RES. DR. GINO BATTISTONE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 2.526 | 3.215 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.150 | 0.076 |
| TOTAL OTHER | 1.803 | 2.842 |
| TOTAL ANNUAL LAB | 4.479 | 6.133 |
| TOTAL INHOUSE | 3.735 | 5.116 |
| TOTAL INHOUSE RDT&E | 1.782 | 2.198 |
| ANNUAL OPERATING COST | 0.861 | 1.148 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 82 | 1 | 24 | 58 |
| CIVILIAN | 21 | 2 | 11 | 10 |
| TOTAL | 103 | 3 | 35 | 68 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 4 | 9.852 | 5.696 | 14.153 | 29.701 | 2.548 | 2.702 |

...MISSION

DEVELOP TECHNIQUES TO TREAT WAR RELATED MAXILLOFACIAL INJURIES AND DENTAL DISEASES. PREVENTION AND CONTROL OF DENTAL DISEASE. TO PROVIDE DENTAL RESIDENCY PROGRAMS. TO PROVIDE A DENTAL CLINIC FOR RESEARCH AND TRAINING.

...CURRENT IMPORTANT PROGRAMS

BIODEGRADABLE MATERIALS FOR LONG TERM SLOW RELEASE AND ORGAN REPLACEMENT
USE OF SALIVA FOR DETECTING EXPOSURE TO CHEMICAL AGENTS IN THE FIELD
R&D OF NEW AND IMPROVED DENTAL MATERIALS FOR MILITARY USE WORLD-WIDE
STUDIES ON METHODS OF IMPROVING COMBAT CONTAMINATED WOUND HEALING
STUDIES FOR IMPROVING METHODS OF CONTROLLING INFECTIONS IN COMBAT WOUNDS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

TEST AND EVALUATE THE PHYSICAL, CHEMICAL AND MECHANICAL PROPERTIES OF DENTAL METALS, ALLOYS, PLASTICS AND POLYMERS. EVALUATE CHANGES DUE TO ENVIRONMENT AND TRANSPORTATION. CONDUCT RESEARCH IN MICROBIOLOGY, CHEMISTRY, BIOCHEMISTRY, IMMUNOLOGY, RADIATION EFFECTS, PHARMACOLOGY, PHYSIOLOGY, HISTOLOGY & PATHOLOGY AS THEY RELATE TO DENTAL MILITARY RES. CONDUCT EPIDEMIOLOGICAL STUDIES ON TRAUMA, DISEASE, MAN MACHINE INTERFACE.TRAUMA AND FIELD DENTAL EMERGENCIES. STUDY MEANS OF PREVENTING ORAL DISEASE. STUDY THE PSYCHOLOGY OF DENTAL TREATMENT ACCEPTANCE.STUDY NEW MATERIALS AND METHODS MORE CLINICALLY EFFECTIVE IN THE FIELD. DEVELOP AND EVALUATE NEW TECHNIQUES AND NEW MATERIALS TO TREAT COMBAT WOUNDS AND TO TEST THESE IN VARIOUS BIOLOGIC MEDIA. DISSEMINATE AS PRACTICAL ALL INFORMATION TO THE FIELD.

INSTALLATION: INSTITUTE OF SURGICAL RESEARCH FT.SAM HOUSTON,TX.

CDR. COL. BASIL A. PRUITT TECH. DIR. DR. ARTHUR D. MASON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 4.144 | 3.400 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 4.448 | 4.418 |
| TOTAL ANNUAL LAB | 8.592 | 7.818 |
| TOTAL INHOUSE | 7.834 | 7.788 |
| TOTAL INHOUSE RDT&E | 3.386 | 3.370 |
| ANNUAL OPERATING COST | 1.230 | 1.450 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 157 | 16 | 46 | 111 |
| CIVILIAN | 79 | 4 | 31 | 48 |
| TOTAL | 236 | 20 | 77 | 159 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 26.424 | 1.800 | 22.400 | 50.624 | 4.340 | 4.300 |

...MISSION

INVESTIGATES PROBLEMS OF MECHANICAL AND THERMAL INJ THEIR COMPLICATIONS.
CARES FOR PATIENTS WITH SUCH INJURIES.
TEACHES AND TRAINS OTHER PERSONNEL IN THE MANAGEMENT OF SUCH PATIENTS.
CONDUCTS INVESTIGATIVE STUDIES AT BOTH THE BASIC AND CLINICAL LEVELS.

...CURRENT IMPORTANT PROGRAMS

BURN INFECTION, TREATMENT & PREVENTION.
METABOLISM & NUTRITIONAL EFFECTS OF BURN INJURY IN SOLDIERS.
INFECTION & MICROBIOLOGIC SURVEILLANCE OF TROOPS WITH THERMAL INJURY.
ALTERATION OF HOST RESISTANCE IN BURNED SOLDIERS.
ASSESSMENT OF L-TRIIODOTHYRONINE THERAPY IN THERMALLY INJURED PATIENTS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

OPERATES 40 BEDS FOR SERIOUSLY BURNED AND INJURED PATIENTS. PROVIDES CLINICAL LABORATORY SUPPORT AND RESEARCH CAPABILITIES IN THE FIELDS OF PATHOLOGY, MICROBIOLOGY, EXPERIMENTAL SURGERY, & BIOCHEMISTRY. MAINTAINS AN ANIMAL COLONY, ELECTRONIC SHOP, MACHINE SHOP, SURGICAL LIBRARY, AND METABOLIC CHAMBER.

PROVIDES CLINICAL AND LABORATORY SUPPORT AND RESEARCH CAPABILITY IN THE FIELDS OF PATHOLOGY, INCLUDING USE OF ELECTRON MICROSCOPE, MICROBIOLOGY, EXPERIMENTAL SURGERY, AND BIOCHEMISTRY. MAINTAINS AN ANIMAL COLONY, ELECTRONIC SHOP, SURGICAL LIBRARY, METABOLIC CHAMBER, AND COMPUTER FACILITY.

INSTALLATION: LARGE CALIBER WEAPONS SYSTEMS LAB DOVER,N.J.

CDR. COL. J. E. BROWN TECH. DIR. MR. H. L. GRUNDLER

| PROGRAM | PROGRAM DATA BY FISCAL YEAR (MILLION $)<br>1983<br>(ACTUAL) | <br>1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 120.064 | 114.430 |
| TOTAL PROCUREMENT | 57.196 | 56.220 |
| TOTAL O&M | 10.193 | 8.250 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 187.453 | 178.900 |
| TOTAL INHOUSE | 133.167 | 125.620 |
| TOTAL INHOUSE RDT&E | 66.974 | 62.250 |
| ANNUAL OPERATING COST | 24.750 | 25.370 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 27 | 1 | 19 | 8 |
| CIVILIAN | 1734 | 82 | 1050 | 684 |
| TOTAL | 1761 | 83 | 1069 | 692 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 11 | 189.951 | 219.627 | 50.343 | 459.921 | 17.732 | 27.272 |

...MISSION
MAINTAIN A STRONG BASIC AND EXPLORATORY TECHNOLOGY BASE. DES AND RES WPNS SYS-GUN/AMMO,LARGER THAN 40MM FOR TANKS,ARTY,MORTAR,RECOILLESS GUNS ,AIR DEFENSE,MINES AND DEMO SYS,EXPLOS AND WHDS. ENG SPT DURING PROCUREMENT,PRODUCTION AND FIELD USE. PREVENT TECHNOLOGICAL SUPRISE.

...CURRENT IMPORTANT PROGRAMS
SPT PM-CAWS DSWS,M509 AND M483 PROJ,M692 ADAM, XM718 RAM
SPT PM-TANK MAIN 120MM AMMO/GUN
SPT PM-NUCL PERSHING 2,XM785,XM753 8 INCH PROJ,XM266
SCATTERABLE MINE SYSTEMS-MOPMS,GEMMS,GRATMS AND VOLCANO
ARTILLERY-GUN PROPULSION INCL EM,CHG DSG,REDUCED WEAR & EROSION,& SADARM

...FUNCTIONS/EQUIPMENT/CAPABILITIES
DEVELOP NEW ITEMS. THE IGNITION,RHEOLOGY AND COMB. LAB WAS ACCEPTED AND IS OPERATIONAL. THE NEW ENERGETICS LAB WAS COMPLETED,ACCEPTED AND IS OPERATIONAL. FACILITIES AND EQUIPMENT RESOURCES ARE CONTAINED IN COMPLEX OF ENG AND LAB BLDGS
15 ADMIN BLGS, 32LAB BLDGS AND 47 STORAGE BLDGS.

INSTALLATION: LETTERMAN ARMY INSTITUTE OF RESEARCH PRESIDIO,S.F.,CA.

CDR. COL. THOMAS F. ZUCK

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 12.242 | 17.027 |
| TOTAL PROCUREMENT | 0.041 | 0.000 |
| TOTAL O&M | 0.248 | 0.269 |
| TOTAL OTHER | 3.990 | 4.366 |
| TOTAL ANNUAL LAB | 16.521 | 21.662 |
| TOTAL INHOUSE | 13.065 | 15.494 |
| TOTAL INHOUSE RDT&E | 8.786 | 10.859 |
| ANNUAL OPERATING COST | 0.000 | 4.593 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 158 | 33 | 97 | 61 |
| CIVILIAN | 117 | 14 | 51 | 66 |
| TOTAL | 275 | 47 | 148 | 127 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 9 | 83.520 | 62.091 | 274.940 | 420.551 | 34.514 | 10.556 |

...MISSION

SUPPORT CLINICAL INVESTIGATION PROJECTS RECOMMENDED BY CDR, LETTERMAN ARMY MEDICAL CENTER(LAMC). THE INSTITUTE ALSO PERFORMS OTHER MEDICAL RESEARCH ACTIVITIES AS DIRECTED BY THE CG, US ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND.

...CURRENT IMPORTANT PROGRAMS

PROVIDES A GENERAL MILITARY MEDICAL RESEARCH CAPABILITY AND CONDUCTS RESEARCH IN THE AREAS OF DERMAL PROTECTION AGAINST BIOLOGICAL, CHEMICAL, AND RADIOLOGICAL HAZARDS; BATTLEFIELD CASUALTY MANAGEMENT; EFFECTS OF MILITARY LASERS; EXPERIMENTAL PSYCHOLOGY; MILITARY TRAUMA AND RESUSCITATION; BLOOD PRESERVATION; CHRONIC MAMALIAN TOXICOLOGY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

AT THE LAIR IS A MULTIDISCIPLINARY APPROACH TO THE PHYSIOLOGY OF ACUTE COMBAT INJURY, SKIN PHYSIOLOGY, AND REPELLENT SCIENCE BASE. THE 6.2 PROGRAM ADDRESSES MANAGEMENT OF WOUNDS FROM FIELDED AND ANTICIPATED WEAPONS SYSTEMS, ANTI-SHOCK DRUGS, BLOOD SUBSTITUTES AND PRESERVATION SYSTEMS, PREVENTION, DIAGNOSIS AND TREATMENT OF MILITARY LASER INJURIES, AND HEALTH EFFECTS OF LOW LEVEL LASER EXPOSURE. IN SUPPORT OF MEDICAL DEFENSE AGAINST CHEMICAL WARFARE, THE PROGRAM ADDRESSES SKIN DECONTAMINATION TECHNOLOGY AND TOXICOLOGY ASSESSMENT OF ANTIDOTES AND DECONTAMINATION MATERIALS.

INSTALLATION: MATERIALS AND MECHANICS RESEARCH CENTER WATERTOWN MA

DIR. DR. E. S. WRIGHT CDR. COL. L. ROSS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 40.722 | 29.840 |
| TOTAL PROCUREMENT | 0.050 | 2.615 |
| TOTAL O&M | 5.599 | 4.968 |
| TOTAL OTHER | 0.074 | 0.056 |
| TOTAL ANNUAL LAB | 46.445 | 37.379 |
| | | |
| TOTAL INHOUSE | 24.495 | 20.445 |
| TOTAL INHOUSE RDT&E | 19.698 | 16.009 |
| ANNUAL OPERATING COST | 7.400 | 8.100 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 16 | 1 | 19 | 3 |
| CIVILIAN | 610 | 73 | 238 | 372 |
| TOTAL | 626 | 74 | 257 | 375 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 37 | 352.000 | 88.261 | 48.375 | 488.636 | 15.294 | 21.919 |

...MISSION

MANAGE THE DARCOM STRUCTURAL MATERIALS AND MECHANICS PROGRAM AS LEAD LAB FOR MATERIALS,MECHANICS AND MATERIALS TESTING TECHNOLOGY.CONDUCT RESEARCH AT THE FOREFRONT OF TECHNOLOGY TO PROVIDE THE ADVANCED MATERIALS REQUIRED FOR PRESENT AND FUTURE ARMY WEAPONS SYSTEMS AT REASONABLE COSTS.

...CURRENT IMPORTANT PROGRAMS

METAL AND ORGANIC MATRIX COMPOSITES FOR LIGHTWEIGHT MATERIEL APPLICATION
ADVANCED ARMOR AND ARMOR PENETRATOR MATERIALS INCLUDING LASER HARDENING
STRUCTURAL INTEGRITY,NDT,AND LIFE PREDICTION/RELIABILITY MECHANICS
CERAMICS FOR ELECTRO-OPTICAL,ENGINE,AND GUN TUBE APPLICATIONS
MATERIALS PROCESSING AND CHARACTERIZATION: METALS ORGANICS AND CERAMICS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THE CENTER POSSESSES THE IN-HOUSE EXPERTISE & FACILITIES TO PERFORM R&D PROJECTS RANGING FROM THE SYNTHESIS OF NEW AND IMPROVED MATERIALS AND DESIGNS TO THE PROTOTYPE MANUFACTURE OF COMPONENTS FOR ARMY WEAPONS SYSTEMS,METALS PROCESSING EQUIPMENT INCLUDES CASTING,FORGING,ROLLING,HEAT TREATING,JOINING,PLATING,ISOSTATIC PRESSING,VACUUM ARC MELTING,AND MACHNING.CERAMIC PROCESSING EQUIP: SLIP CASTING,HOT PRESSING,SINTERING AND GRADIENT FURNACE CRYSTAL GROWTH.POLYMER/COMPOSIT PROCESSING EQUIPMENT: INJECTION MOLDING,LAMINATING,TAPE LAYUP,VACUUM FORMING,FILM FORMING AND ORIENTATION,FILIMENT WINDING,PULTRUSION,FOAM PROCESSING & PILOT POLYMER PRODUCTION.QC AND NDT EQUIPMENT:ULTRASONICS,XRAY & NEUTRON RADIOGRAPHY, SPECTROSCOPY,HOLOGRAPHY,CHEMICAL ANALYSIS,METALLOGRAPHY AND OPTICS. OTHER:U AND BE MACHINING,BALLISTIC RANGE AND POWDER CHARACTERIZATION.

INSTALLATION: MEDICAL BIOENGINEERING R&D LABORATORY FT.DETRICK,MD.

CDR. COL THOMAS L. TRUDEAU

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 15.992 | 25.130 |
| TOTAL PROCUREMENT | 0.006 | 0.000 |
| TOTAL O&M | 0.047 | 0.089 |
| TOTAL OTHER | 1.035 | 1.044 |
| TOTAL ANNUAL LAB | 17.080 | 26.263 |
| TOTAL INHOUSE | 6.666 | 7.086 |
| TOTAL INHOUSE RDT&E | 5.578 | 5.953 |
| ANNUAL OPERATING COST | 2.036 | 2.328 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 33 | 2 | 25 | 8 |
| CIVILIAN | 103 | 17 | 47 | 56 |
| TOTAL | 136 | 19 | 72 | 64 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5 | 45.193 | 27.300 | 34.108 | 106.601 | 3.588 | 3.549 |

...MISSION
CONDUCTS R&D ON MEDICAL DENTAL AND PEST MANAGEMENT MATERIEL
PERFORMS R&D ON NEW DELIVERY SYSTEMS FOR INSECTICIDE DISPERSAL
PERFORMS R&D ON MILITARILY UNIQUE POLLUTANTS FROM ARMY INDUSTRIAL OPER
CONDUCTS R&D OF SOLDIER OCCUPATIONAL HEALTH HAZARDS

...CURRENT IMPORTANT PROGRAMS
THE FOLLOWING ITEMS WERE TYPE CLASSIFIED: TWO HELICOPTER SLUNG PESTICIDE DISPERSAL UNITS,A PORTABLE BACKPACK SPRAYER,AN ULTRA LOW VOLUME SPRAYER, FIELD DENTAL X-RAY APPARATUS AND A FIELD DENTAL X-RAY PROCESSOR
HLTH EFF RSCH:SMOKES OBSC,WEAPON SYS,SYN FUEL,ENVIRO QUAL,FLD SAN/WATER
DEVELOP ENVIRO QLTY & OCCUP HLTH CRITERIA ON MIL CHEMICALS

...FUNCTIONS/EQUIPMENT/CAPABILITIES
DESIGN,DEVELOP & FABRICATE PROTOTYPE & TEST MODELS OF MIL MED MAT
PRODUCE LIMITED QUANTITIES OF MED MAT FOR URGENT MIL REQ
DESIGN DEVELOP & FABRICATE PEST MGT EQUIP AND SYSTEMS
DESIGN,DEVELOP & FABRICATE PROTOTYPE AND TEST MODELS OF MIL DENTAL MAT
PERFORM HEALTH HAZARD ASSESSMENT ON ARMY CHEMICALS
PERFORM UNIT PROCESS ENGINEERING RSCH ON WASTEWATER IN SUPPORT OF FIELD ARMY AND OCCUP HEALTH AND ENVIRO QUALITY CRITERIA
CONDUCTS HEALTH HAZARD ASSESSMENT FOR MATERIEL DEVELOPERS OF SMOKES OBSURANTS AND SYNFUELS; DEVISES STRATEGIES TO ELIMINATE EXPOSURE OR DEFINE CRITERIA FOR SAFE EXPOSURE STANDARDS.

INSTALLATION: MEDICAL R & D COMMAND FT.DETRICK,MD.

CDR. MG GARRISON RAPMUND

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 12.118 | 15.917 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.307 | 0.352 |
| TOTAL OTHER | 2.739 | 2.949 |
| TOTAL ANNUAL LAB | 15.164 | 19.218 |
| TOTAL INHOUSE | 14.362 | 17.785 |
| TOTAL INHOUSE RDT&E | 11.316 | 14.484 |
| ANNUAL OPERATING COST | 4.000 | 4.190 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 61 | 29 | 55 | 6 |
| CIVILIAN | 140 | 1 | 2 | 138 |
| TOTAL | 201 | 30 | 57 | 144 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 0.000 | 38.757 | 0.000 | 38.757 | 0.632 | 0.997 |

...MISSION
ADMINISTRATION AND COORDINATION OF THE ARMY MEDICAL RDTE PROGRAM
PROGRAM LIMITED TO UNIQUE MILITARY PROBLEMS WITHIN US & OCONUS
INFECTIOUS DISEASES AND COMBAT DENTAL FUNCTIONS OF FIVE US NAVY LABORATORIES ARE FUNDED BY THE US ARMY AS LEAD AGENCY, BY DIR. OF CONGRESS.

...CURRENT IMPORTANT PROGRAMS
CARE OF THE WOUNDED
PREVENTION AND CONTROL OF INFECTIOUS DISEASES
ENHANCEMENT OF MILITARY PERFORMANCE
PROTECTION AGAINST MILITARY ENVIRONMENTAL HAZARDS
MEDICAL DEFENSE AGAINST CHEMICAL WARFARE

...FUNCTIONS/EQUIPMENT/CAPABILITIES
SERVES AS AN ADMINISTRATIVE HEADQUARTERS FOR THE ARMY MEDICAL DEPARTMENT

INSTALLATION: MEDICAL RESEARCH INSTITUTE CHEMICAL DEFENSE ABERDEEN PROV. GR.,MD

CDR. COL. DUANE E. HILMAS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 85.239 | 86.043 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.024 | 0.054 |
| TOTAL OTHER | 2.555 | 2.730 |
| TOTAL ANNUAL LAB | 87.818 | 88.827 |
| | | |
| TOTAL INHOUSE | 17.005 | 19.405 |
| TOTAL INHOUSE RDT&E | 14.426 | 16.621 |
| ANNUAL OPERATING COST | 2.360 | 2.480 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 85 | 33 | 47 | 38 |
| CIVILIAN | 159 | 22 | 69 | 90 |
| TOTAL | 244 | 55 | 116 | 128 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 81 | 36.426 | 15.345 | 98.429 | 150.200 | 9.246 | 6.160 |

...MISSION
FUNDEMENTAL RES ON MECHANISMS OF ACTION (CW AGENTS,ANTIDOTES & PRETREAT)
DEVELOPMENT OF PRETREATMENT & ANTIDOTE DRUGS (AGAINST CW AGENTS)
DEVELOP & EVALUATE PREVENTION,RESUSCITATION,TREATMENT & MANAGEMENT
METHODS FOR CHEMICAL CASUALTIES AND ASSIST IN THEIR IMPLEMENTATION

...CURRENT IMPORTANT PROGRAMS
MEDICAL CHEMICAL DEFENSE SCIENCE BASE/MECHANISM OF ACTION AGENTS/DRUGS
DEVELOP SOLDIER CW AGENT ANTIDOTES & PRETREATMENT REGIMEN
DEVELOP BIOMEDICAL MODELS TO EVALUATE DRUG EFFICACY
EVALUATE BEHAVIORAL/PERFORMANCE DECREMENTS FROM CW AGENTS/ANTIDOTES
DEVELOP METHODS FOR MGT & TREATMENT OF MASS CW CASUALTIES

...FUNCTIONS/EQUIPMENT/CAPABILITIES
MODERN 7000 SQ FT ANIMAL HOLDING FACILITY & CHEMICAL SURETY AREA
TECH LIBRARY HAS 5062 BOOKS, 837 JOURNAL TITLES, MANY DATA BASES
COMPLETE VIDEO PRODUCTION FACILITY & COMPUTER FACILITY (WITH NETWORK)
MEDICAL MAINTENANCE FACILITY, LABORATORY SUPPLY FACILITY
RADIOISOTOPE CHEMICAL DRUGS & BIOCHEMICAL ANALYSIS
BEHAVIORAL TESTING LABORATORY
LIQUID, GAS, COLUMN & AFFIMITY CHROMATOGRAPHY, ANAL ULTRACENTRIFUGE
ELECTROPHORESIS, SPECTROSCOPY, FLUOROMETRY, AND SPECTROPOLARIMETRY
GE MASS SPECTROMETRY AND ELECTRON SPIN RESONANCE
AMINO ACID ANALYSIS AND PEPTIDE SEQUENCING, MONOCLONAL ANTIBODIES
PHYSIOLOGY, PHARMACOLOGY AND NEUROPHARMACOLOGY LABORATORIES
ELECTRON MICROSCOPY SEM, TISSUE CULTURE, CELL CLONING, RECEPTOR ANALYSIS

INSTALLATION: MEDICAL RSCH INST OF INFECTIOUS DISEASES FT.DETRICK,MD.

CDR. COL. D. L. HUXSOLL

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 27.916 | 35.880 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.493 | 0.410 |
| TOTAL OTHER | 6.155 | 7.187 |
| TOTAL ANNUAL LAB | 34.564 | 43.477 |
| TOTAL INHOUSE | 23.081 | 24.092 |
| TOTAL INHOUSE RDT&E | 16.483 | 16.495 |
| ANNUAL OPERATING COST | 7.545 | 8.247 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 305 | 46 | 104 | 201 |
| CIVILIAN | 205 | 41 | 92 | 113 |
| TOTAL | 510 | 87 | 196 | 314 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 43 | 104.136 | 20.718 | 209.699 | 334.553 | 18.763 | 11.000 |

...MISSION

PERFORM STUDIES ON THE PATHOGENESIS,DIAGNOSIS,PROPHYLAXIS,TREATMENT AND EPIDEMIOLOGY OF NATURALLY OCCURING INFECTIOUS DISEASE OF MILITARY IMPORTANCE WITH EMPHASIS ON PROBLEMS ASSOCIATED WITH THE MEDICAL DEFENSE AGAINST BIOLOGICAL AGENTS.

...CURRENT IMPORTANT PROGRAMS

ANTHRACIS DISCOVERED TO CONTAIN A PLASMID WHICH CODES
RIFT VALLEY FEVER STUDIES DETERMINED THAT G1 AND G2 POLYPEPT
RESPONSIBLE FOR THE DEVELOPMENT OF ANTIBODIES THAT PROTECT EXP
ANIMALS FROM INFECTION.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

JUNIN VIRUS IS HIGHLY INFECTIOUS AS A SMALL PARTICLE AEROSOL
THE ELISA FOR VEE-IGM CAPTURE SYSTEM WAS DEVELOPED AND STAND
THE GENE FOR PROTECTIVE ANTIGEN WAS ISOLATED FROM ANTHRAX PL
IN E.COLI AND THE BACTERIUM PRODUCED PA THAT WAS FUNCTIONAL
NEUTRALIZATION TEST DEVELOPED FOR LASSA FEVER AND CAN BE USED
POTENTIAL DONORS FOR HIGH TITERING ANTIBODY THAT PROVIDES GO
MURAMYL DIPEPTIDE,WHEN DELIVERED BY LIPOSOMES,WAS USED TO
TREAT MICE INFECTED WITH RIFT VALLEY FEVER.

INSTALLATION: MISSILE LABORATORY REDSTONE ARSENAL, AL.

CDR. MAJ. GEN. JERRY MAX BUNYARD DIR. DR. WILLIAM C. MCCORKLE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1988 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 177.058 | 156.546 |
| TOTAL PROCUREMENT | 22.688 | 80.286 |
| TOTAL O&M | 88.754 | 19.256 |
| TOTAL OTHER | 24.965 | 23.692 |
| TOTAL ANNUAL LAB | 258.460 | 229.780 |
| TOTAL INHOUSE | 104.426 | 104.819 |
| TOTAL INHOUSE RDT&E | 69.028 | 64.232 |
| ANNUAL OPERATING COST | 28.147 | 24.580 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 45 | 4 | 81 | 14 |
| CIVILIAN | 1170 | 70 | 776 | 894 |
| TOTAL | 1215 | 74 | 807 | 408 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 11000 | 664.000 | 224.000 | 252.000 | 1140.000 | 96.400 | 90.000 |

...MISSION

MNGE & CONDUCT RSCH, EXPL & ADV DEV FOR ASSGN MATL; PROV S&E SPT TO OTHER ACTIVITIES; PLANS, DIRECTS & CONDUCTS RSCH STUDIES & PRGMS TO ADV SYS ENGR & TESTING TECH; PROV CENTRAL ENGR BASE FOR DESIGN & MFG OF PROTOTYPE SYS & COMPONMENTS

...CURRENT IMPORTANT PROGRAMS

EXPLORATORY DEV ON OVER ARMOR TECHNOLOGY SYNTHESIS
KINETIC ENERGY RKT
INFRARED ADJUNCT GUIDANCE
DEV OF FIBER OPTICS GUIDED MSL
DEV MULTI-ENVIRON ACTIVE RF SEEKER MISSION.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

LAB IS EQUIPPED TO STUDY PROBLEMS IN PROP,AERO,G&C,& STRUCTURES,MAJOR FAC IS MCMORROW LAB WHICH HOUSES MAJORITY OF AML. SOME UNIQUE FAC ARE: ADV SIM CNTR; A COMPUTER COMPLEX SURROUNDED PERIPHERALLY BY 8 ENVIRON EFFECTS SIMULATORS; MSL COMPUTER SOFTWRE/HDWE CNTR; SIG EVAL CHAMBERS; ARMY MSL OPTICAL RANGE DESIGNED TO MEASURE LASER RADAR SIG. MAINTAINS AND OPERATES 7 MAJOR TEST AREAS WHICH ENCOMPASS FLIGHT STATIC ENVIRON & FUNCTIONAL TEST; STATE-OF-THE-ART FAC & EQUIP SUCH AS LASER TRACKERS & ELECTRO-MAGNETIC RADAR SENSORS, ENGR DESIGN & DEV CORRECTIONS TO DESIGN DEFICIENCIES IN FIELDED WPN SYS. PERFORMS ARMY LEAD LAB FUNCTION IN GUID & CONTROL/TERMINAL HOMING TECH MECH, ELECT & ELEC FAB & ASSY & HYBRID MICROCIRCUITRY DESIGN ARE AVAILABLE, SMOKE CHARACTERIZATION FAC IS ALSO AVAILABLE

INSTALLATION: NATICK R & D CENTER NATICK,MA.

CDR. COL. DAVID L. SAUNDERS TECH. DIR. DR. ROBERT J. BYRNE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 47.813 | 48.160 |
| TOTAL PROCUREMENT | 0.863 | 0.189 |
| TOTAL O&M | 16.728 | 15.591 |
| TOTAL OTHER | 2.829 | 2.934 |
| TOTAL ANNUAL LAB | 67.783 | 66.874 |
| | | |
| TOTAL INHOUSE | 55.417 | 55.202 |
| TOTAL INHOUSE RDT&E | 36.859 | 37.672 |
| ANNUAL OPERATING COST | 8.495 | 9.150 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 105 | 3 | 40 | 65 |
| CIVILIAN | 1092 | 77 | 391 | 701 |
| TOTAL | 1197 | 80 | 431 | 766 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 24 | 527.067 | 55.340 | 277.817 | 860.224 | 28.497 | 22.850 |

...MISSION

CHEMICAL AND BALLISTIC HARDENED TACTICAL SHELTERS
FOOD/FOOD SYS' CONTAINERS AND PACKAGING. PERF ILS FUNC. ENG SPT TO DLA AND GSA PROC. FIRST PROD BUY/FIELDING OF ARMY MANAGED ITEMS.
BACTERIOLOGY LAB EQUIP FOR INVES OF PATHOGENIC MICROORGANISMS

...CURRENT IMPORTANT PROGRAMS

CHEMICAL PROTECTION
ACCOMP R&D IN THE PHYS AND BIOL SCI AND ENGR TO MEET MIL NEEDS
LASER/HIGH ENERGY PROTECTION
MICROCLIMATE COOLING PROGRAM FOR GROUND AND AIR COMBAT VEHICLES
COMBAT FIELD FEEDING SYSTEM.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

RESOLUTION MASS SPECTROMETER FOR ANAL OF VOLATILE COMPOUNDS' FEBETRON AND PERS EQUIP' AIRDROP' FIELD SHELTERS AND EQUIPAGE' FIELD ORG EQUIP' MACHINE USED FOR FOOD OXIDATION' SCANNING TRANSMISSION ELECTRON MICROSCOPE' LASER LAB FOR EVAL OF HIGH ENERGY LASERS ON CLO AND RELATED MAT' DYEING AND FINISHING LAB FOR STUDIES OF TEXTILES' COMPUTER GENERATED SYS OF CLO PATTERNS TO OUTPUT COMPL TARIFF OF SIZES FROM ONE MASTER' CLIMATIC CHAMBERS W/TEMPS -57C TO 74C W/WIND AND RAIN' FLAME PROT LAB AND FACILITY INCL OUTDOOR FIRE PIT' AIRCRAFT ROLLER CONVEYER TEST FAC' DROP TEST FAC' 40 X 40 FT RAINCOURT' FOOD PROC LAB' FOOD SYS EQUIP LAB' EXPERIMENTAL KITCHEN' SENSORY EVALUATION LAB' HORIZONTAL IMPACT TESTING MACHINE' UNIVAC 1106, IBM 4341, PRIME 750 CAD/E, AND PRIME 2250 COMPUTERS WITH PERIPHERAL EQUIPMENT AND SOFTWARE.

INSTALLATION: NIGHT VISION & ELECTRO OPTICS LABORATORY FT.BELVOIR,VA.

DIR. DR. LOUIS M. CAMERON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 75.088 | 83.375 |
| TOTAL PROCUREMENT | 94.357 | 114.806 |
| TOTAL O&M | 2.844 | 2.257 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 172.289 | 200.438 |
| TOTAL INHOUSE | 32.036 | 32.825 |
| TOTAL INHOUSE RDT&E | 25.614 | 26.568 |
| ANNUAL OPERATING COST | 3.209 | 3.320 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 32 | 0 | 6 | 26 |
| CIVILIAN | 470 | 39 | 216 | 254 |
| TOTAL | 502 | 39 | 222 | 280 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 88 | 180.639 | 27.186 | 20.000 | 227.825 | 32.000 | 31.237 |

...MISSION

NV&EOL IS RESPONSIBLE FOR PROVIDING THE ARMY WITH AN ELECTRO-OPTICAL CAPABILITY THAT WILL ALLOW IT TO OPERATE WITH NEAR DAYLIGHT EFFICIENCY. THE SYSTEMS DEV PROGRAM IS STRUCTURED AROUND A STRONG TECHNOLOGY BASE WHICH CONSISTS OF FIR, ELECTRO-OPTICS, LASERS AND VISIONICS.

...CURRENT IMPORTANT PROGRAMS

EPITAXIAL GROWTH FOR COMMON MOD AND 2ND GEN DETECTORS
AUTOMATION OF FLIR AND MULTI-SENSORS
NEAR INFRARED AND FAR INFRARED TUNABLE LASERS
THERMAL WEAPONS SIGHT
NIGHT VISION GOGGLES,AN/PVS-7.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MAJOR FACILITIES INCLUDE: NIGHT VISION SYSTEM LAB, IR DETECTOR FABR AND ANALYSIS FACILITY, SURFACE RESEARCH FACILITY, FOCAL PLANE ARRAY TEST FACILITY, IR OPTICAL TEST FACILITY, IMAGE INTENSIFIER TUBE TESTING FACILITY, SEMICONDUCTOR MATERIALS RESEARCH FACILITY, ELECTRONICS TEST FACILITY, INTERACTIVE IMAGE PROCESSING FACILITY, LASER RANGES, 3-D MULTI SPECTRAL SEARCH SIMULATOR, SCIENTIFIC COMPUTER CENTER, FIRING TEST RANGE, EO/IR IMAGE EVALUATION FACILITY, AND LASER MATERIAL EVALUATION FACILITY.

INSTALLATION: RESEARCH INST FOR BEHAVIORAL & SOCIAL SCI ALEXANDRIA, VA.

CDR. COL. L. NEALE COSBY TECH. DIR. DR. EDGAR M. JOHNSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 39.892 | 46.352 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 8.996 | 10.548 |
| TOTAL OTHER | 1.351 | 1.271 |
| TOTAL ANNUAL LAB | 50.239 | 58.171 |
| TOTAL INHOUSE | 19.182 | 24.030 |
| TOTAL INHOUSE RDT&E | 17.537 | 22.589 |
| ANNUAL OPERATING COST | 6.017 | 8.627 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 31 | 0 | 30 | 1 |
| CIVILIAN | 374 | 166 | 271 | 103 |
| TOTAL | 405 | 166 | 301 | 104 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 3.008 | 51.310 | 3.191 | 57.509 | 0.550 | 0.700 |

...MISSION

TO MAXIMIZE COMBAT EFFECTIVENESS THROUGH RESEARCH IN THE ACQUISITION DEVELOPMENT AND UTILIZATION OF SOLDIERS IN MILITARY SYSTEMS

...CURRENT IMPORTANT PROGRAMS

OFFICER SELECTION BATTERY
COMPUTERIZED TUTOR
REALISTIC AIR DEFENSE ENGAGEMENT SIMULATION
STINGER REVERSE ENGINEERING
ARMY DEVELOPMENT AND EMPLOYMENT AGENCY TRAINING SYSTEMS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THREE RESEARCH LABORATORIES,MANPOWER PERSONNEL,TRAINING AND SYSTEMS ARE DIVIDED INTO 8 FIELD UNITS AT PRESIDIO OF MONTEREY,FT BENNING,FT KNOX, FT RUCKER,FT BLISS,FT HOOD, FT LEAVENWORTH, AND EUROPR. PEOPLE RELATED RESEARCH IN AVIATION ON SYSTEMS INTEGRATION,COMMAND AND CONTROL,MANEUVER ARMS AND UNIT TRAINING/EVALUATION.7 TECH AREAS ARE AT ARI HQ PERSONNEL UTILIZATION,LEADERSHIP/MANAGEMENT,SELECTION,CLASSIFICATION,SYSTEMS MANNING,BATTLEFIELD INFO SYSTEMS,TRWG AND INSTRUCTIONAL TECH SYSTEMS.5 SCIENTIFIC COORDINATION OFFICES AT FT SILL,EUROPE, FORSCOM,TRADOC,PM TRADE.IN HOUSE EXPERIMENTAL FACILITIES INCLUDE LABORATORY AREAS-COMPUTER THAT PERMIT REALTIME EXPERIMENTATION GAMING AND SIMULATION WITH EXTERNAL LINES TO PROVIDE FLEXIBILITY.

INSTALLATION: RSCH INSTITUTE OF ENVIRONMENTAL MEDICINE NATICK,MA.

CDR. COL. ERNEST M. IRONS JR.

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 5.516 | 5.734 |
| TOTAL PROCUREMENT | 0.004 | 0.000 |
| TOTAL O&M | 0.066 | 0.060 |
| TOTAL OTHER | 1.559 | 1.982 |
| TOTAL ANNUAL LAB | 7.145 | 7.776 |
| | | |
| TOTAL INHOUSE | 6.508 | 7.183 |
| TOTAL INHOUSE RDT&E | 4.879 | 5.141 |
| ANNUAL OPERATING COST | 0.000 | 0.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 77 | 6 | 89 | 88 |
| CIVILIAN | 97 | 18 | 59 | 88 |
| TOTAL | 174 | 24 | 98 | 76 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 4 | 60.421 | 18.793 | 28.647 | 107.861 | 4.084 | 6.704 |

...MISSION

CONDUCTS RSCH TO DETERMINE VARIOUS EFFS ON SOLDIER'S LIFE PROC,PERFHLTH.
DEF INTERACTION ENV STRESS,DEF,TECH,EQUIP,PROCED USED TO PROT SOLD EFF.
CONDUCTS RSCH IN PHYS & HLTH EFF OF ARMY PHYSICAL FITNESS TRAINING.
DEV RSCH TECH BASE TO DISCHARGE ARMY SG RESPON AS DOD EXE AGT FOR NUTRI.

...CURRENT IMPORTANT PROGRAMS

DEVELOPMENT OF MEPSCAT.
ASSESS WORK LIMITS IMPOSED ON SOLDIER BY PROTECT REGTS TO CW AGTS.
BIOMED IMPACT OF MIL CLOTHING & EQUIP DESIGN INCL SEL CREW COMPART ENV.
INVESTIGATIONS DIR TOWARD PREV & TREATMENT OF HEAT INJ & COLD INJ.
STRUCT & FUNCT ALTERATIONS CELLS, TISSUES & ORGANS INDUCES EXP ENV EXTR.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THE MAJ EQUIP & FAC CAPABILITIES OF THE LAB INCL, BUT ARE NOT LIMITED TO TWO LGE ALT CHAMBERS,14 SM CLIMATIC CHAMBERS, AAALAC ACCREDITED ANIMAL CARE FACILITIES, ELECTRON MICROSCOPY, UNDERWATER RSCH POOL, COPPER MANIKINS & DIVERSE PHARMACOLOGICAL & PSYCHOLOGICAL MEASURING EQUIP. THE INSTITUTE MAINTAINS A FIELD FACILITY ON THE SUMMIT OF PIKES PEAK, COLO.

INSTALLATION: SIGNALS WARFARE LABORATORY VINT HILL,VA.

CDR. DIR. MR. H. S. HOVEY JR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 46.056 | 48.679 |
| TOTAL PROCUREMENT | 55.903 | 174.406 |
| TOTAL O&M | 3.995 | 7.317 |
| TOTAL OTHER | 0.000 | 0.000 |
| TOTAL ANNUAL LAB | 105.954 | 230.402 |
| | | |
| TOTAL INHOUSE | 8.495 | 10.221 |
| TOTAL INHOUSE RDT&E | 5.739 | 5.831 |
| ANNUAL OPERATING COST | 2.031 | 2.487 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 51 | 0 | 10 | 41 |
| CIVILIAN | 180 | 5 | 93 | 87 |
| TOTAL | 231 | 5 | 103 | 128 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 10 | 3.986 | 29.145 | 6.963 | 40.094 | 3.500 | 5.800 |

...MISSION

PROVIDE THE US ARMY WITH EFFECTIVE TACTICAL COMMUNICATIONS,ELECTRONIC WARFARE AND TACTICAL AND STRATEGIC COMMUNICATIONS,INTELLIGENCE (COMINT). MATERIAL CAPABILITY IN SUPPORT OF THE ARMY'S MISSION.

...CURRENT IMPORTANT PROGRAMS

AN/TSQ-114 TRAILBLAZER
AN/MLQ-34 TACJAM
AN/TLQ-17A TRAFFIC JAM
AN/TRQ-32 TEAMMATE
AN/TSQ-113 AND AN/TSS-11 REAR ECHELON COMINT

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THE US ARMY SIGINALS WARFARE LABORATORY IS LOCATED AT VINT HILL FARMS STATION, WARRENTON, VIRGINIA, IN A FACILITY UNIQUELY SUITED TO ITS COMMUNICATIONS INTERCEPT, PROCESSING, COLLECTION, DIRECTION FINDING AND JAMMING MATERIEL MISSION. FACILITIES AVAILABLE INCLUDE AN ANTENNA FIELD FOR SIGNALS COLLECTION, A COMPUTERIZED SIGNAL ANALYSIS PROCESSING SYSTEM FOR SIGNALS SIMULATION AND ANALYSIS, AND AN IN-HOUSE FACILITY FOR SYSTEM SOFTWARE VERIFICATION AND VALIDATION. THE LAB IS STAFFED WITH THE ELECTRONICS ENGINEERS, TECHNICAL SIGNAL ANALYSIS, OPERATION RESEARCH ANALYSIS, INTEGRATED LOGISTICS SUPPORT PERSONNEL, PRODUCT AND QUALITY ASSURANCE TECHNICIANS, AND PRODUCTION ENGINEERS TO PROVIDE FOR MILITARILY USEFUL EQUIPMENT AND SYSTEM.

INSTALLATION: TANK-AUTO COMMAND R & D CENTER WARREN,MI.

CDR. COL. T. J. HUBER TECH. DIR. DR. H. H. DOBBS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 101.149 | 114.901 |
| TOTAL PROCUREMENT | 591.080 | 1,014.750 |
| TOTAL O&M | 4.252 | 3.900 |
| TOTAL OTHER | 1.178 | 1.295 |
| TOTAL ANNUAL LAB | 697.659 | 1,134.846 |
| TOTAL INHOUSE | 35.282 | 46.741 |
| TOTAL INHOUSE RDT&E | 24.194 | 27.461 |
| ANNUAL OPERATING COST | 12.844 | 13.615 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 36 | 0 | 21 | 15 |
| CIVILIAN | 554 | 14 | 218 | 336 |
| TOTAL | 590 | 14 | 239 | 351 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 11 | 257.152 | 33.284 | 111.777 | 402.213 | 39.600 | 117.445 |

...MISSION
RESPONSIBLE FOR ACCOMPLISHING DESIGN,DEVELOPMENT,AGQUISITION & INITIAL DEPLOYMENT OF ASSIGNED TANK-AUTO WEAPONS/EQUIPMENT SYSTEMS. CONDUCT & MANAGE RESEARCH.PERFORM PROCUREMENT & QUALITY ASSURANCE THRU DEVELOPMENT. PERFORM RELIABILITY-MAINTAINABILITY ASSESSMENT.

...CURRENT IMPORTANT PROGRAMS
COMBAT VEHICLE TRACK & SUSPENSION PROGRAM.
COMBAT VEHICLE SURVIVABILITY THRU THREAT WARING & DATA MGMT.
VEHICLE ELECTRICAL/ELECTRONIC SYSTEMS INTEGRATION.
FUTURE CLOSE COMBAT VEHICLE SYSTEMS.DESIGN & TEST BED DEMO'S.
ADVANCED INTEGRATED PROPULSION SYSTEMS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
VEHICLE BRAKE DYNANOMETER.ENGINE & TRANSMISSION TEST CELLS. VEHICLE COMPONENT/SUBSYSTEM INTEGRATION & EVALUATION.VEHICLE MOTION SIMULATOR.ANALYTICAL PREDICTION OF LAND VEHICLE PERFORMANCE.VEHICLE SIGNATURE MEASUREMENT CAPABILITY.SIX DEGREE OF FREEDOM SIMULATOR SCIENTIFIC & ENGINEERING COMPUTER NETWORK (SENET) FOR COMPUTER AIDED DESIGN (CAD) SERVICES.METAL ANALYSIS WITH MICROPROBE ELECTRON MICROSCOPE ANALYZER & TECHNIQUES.DEVELOPMENT OF IMPROVED ARMOR WELDING,FABRICATION & APPLICATION TECHNIQUES.LOW TEMPERATURE SHOCK & VIBRATION TEST FACILITIES.VEHICLE DYNAMIC SIMULATION FACILITY.IMAGE PROCESSING CAPABILITY. HOLOGRAPIC CAPABILITY FOR LARGE STRUCTURERS.

INSTALLATION: WALTER REED ARMY INSTITUTE OF RESEARCH WASHINGTON,D.C. ✓

DIR. COL. FRANKLIN H. TOP JR DEP. DIR. LTC. FRANK SODETZ JR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 53.062 | 94.098 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 1.972 | 1.960 |
| TOTAL OTHER | 12.246 | 13.288 |
| TOTAL ANNUAL LAB | 67.280 | 109.346 |
| | | |
| TOTAL INHOUSE | 48.344 | 52.189 |
| TOTAL INHOUSE RDT&E | 34.126 | 38.415 |
| ANNUAL OPERATING COST | 2.631 | 4.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 411 | 82 | 386 | 25 |
| CIVILIAN | 598 | 59 | 278 | 320 |
| TOTAL | 1009 | 141 | 664 | 345 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 203 | 383.274 | 58.600 | 0.000 | 441.874 | 10.080 | 20.500 |

...MISSION
PERFORMS,GENERAL MILITARY MEDICINE RESEARCH IN THE AREAS OF DRUG DEV,NEUROPSY,GEN MED & PREV MED SERVES AS COM & CONTROL ELEMENT FOR SPEC FOREIGN ACTIVITIES. PLANS AND CONDUCTS AMEDD COURSES.

...CURRENT IMPORTANT PROGRAMS
BASIC RESEARCH ON MILITARY DISEASES
MILITARY PSYCHIATRY
MICROWAVE INJURY,PREVENTION & TREATMENT
MED EFFECTS OF WEAPONS SYS BLAST OVERPRESSURE
MED ASPECTS OF CHEM WARFARE DEF.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
MAJOR EQUIP & FACILITY CAPABILITY OF THE LAB INCLUDES CHEM ANALY EQUIP, MICRO LABS, MICROWAVE ESPOSURE SYS, BEHAVIORAL RES INSTRU AND ELECTRON MICROSCOPES. ADDT,L RSCH FACILITIES ARE LOCATED IN GERMANY, MALAYSIA, KENYA, BRAZIL, THAILAND AND MARYLAND

TABLE 3A. NAVY R&D LABORATORIES, PROGRAM AND PERSONNEL DATA, FY 1983

| INSTALLATION | FUNDING DATA (MILLIONS $) | | | | PERSONNEL DATA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL | TOTAL INHOUSE | TOTAL RDT&E | INHOUSE RDT&E | TOTAL MIL | TOTAL CIV | PHD MIL | PHD CIV | PROF MIL | PROF CIV |
| AEROSPACE MEDICAL RESEARCH LABORATORY | 4.388 | 4.195 | 3.683 | 3.490 | 37 | 55 | 10 | 10 | 14 | 23 |
| *AIR DEVELOPMENT CENTER | 318.349 | 120.514 | 171.072 | 80.647 | 254 | 2225 | 5 | 43 | 63 | 1305 |
| BIODYNAMICS LABORATORY | 4.741 | 3.885 | 4.014 | 3.158 | 34 | 51 | 3 | 6 | 7 | 27 |
| *BIOSCIENCES LABORATORY | 3.209 | 3.209 | 2.900 | 2.900 | 9 | 6 | 4 | 0 | 5 | 0 |
| CIVIL ENGINEERING LABORATORY | 39.058 | 21.108 | 32.741 | 17.047 | 16 | 345. | 0 | 27 | 7 | 153 |
| *CLOTHING & TEXTILE RESEARCH FACILITY | 3.964 | 3.639 | 2.655 | 2.355 | 1 | 56 | 0 | 1 | 1 | 36 |
| COASTAL SYSTEMS CENTER | 80.727 | 40.132 | 45.215 | 24.846 | 116 | 647 | 0 | 27 | 13 | 364 |
| *DAVID W. TAYLOR SHIP R&D CENTER | 225.056 | 113.757 | 164.647 | 87.503 | 76 | 2478 | 1 | 118 | 23 | 1206 |
| DENTAL RESEARCH INSTITUTE. | 1.733 | 1.698 | 0.874 | 0.839 | 29 | 15 | 8 | 4 | 13 | 6 |
| *ENVIRONMENTAL PREDICTION RESEARCH FACILITY | 6.276 | 2.849 | 5.177 | 2.265 | 14 | 32 | 2 | 8 | 5 | 27 |
| HEALTH RESEARCH CENTER | 4.244 | 3.563 | 3.239 | 2.558 | 30 | 60 | 11 | 10 | 14 | 24 |
| *MEDICAL RESEARCH INSTITUTE | 20.521 | 19.435 | 15.149 | 14.088 | 245 | 171 | 62 | 41 | 78 | 86 |
| MEDICAL RESEARCH UNIT NO.2 | 3.111 | 3.111 | 2.221 | 2.221 | 31 | 58 | 4 | 2 | 20 | 9 |
| *MEDICAL RESEARCH UNIT NO.3 | 4.718 | 4.718 | 3.685 | 3.685 | 29 | 202 | 12 | 17 | 13 | 41 |
| OCEAN R & D ACTIVITY | 48.398 | 20.308 | 46.252 | 18.341 | 16 | 312 | 1 | 76 | 11 | 201 |
| *OCEAN SYSTEMS CENTER | 391.500 | 182.198 | 243.232 | 121.043 | 269 | 2582 | 2 | 181 | 49 | 1382 |
| PERSONNEL RESEARCH & DEVELOPMENT CENTER | 23.608 | 15.941 | 17.604 | 11.696 | 34 | 293 | 4 | 81 | 17 | 208 |
| *RESEARCH LABORATORY | 341.049 | 185.474 | 302.650 | 163.130 | 137 | 3090 | 2 | 664 | 40 | 1505 |
| SUBMARINE MEDICAL RESEARCH LABORATORY | 2.994 | 2.994 | 1.995 | 1.995 | 36 | 55 | 8 | 10 | 14 | 24 |
| *SURFACE WEAPONS CENTER | 507.924 | 216.508 | 279.827 | 127.319 | 103 | 5089 | 0 | 241 | 35 | 2307 |
| UNDERSEA RANGES DEPARTMENT | 50.554 | 9.928 | 37.259 | 8.829 | 41 | 22 | 0 | 2 | 9 | 13 |
| *UNDERWATER SYSTEMS CENTER | 385.854 | 164.772 | 174.225 | 94.004 | 79 | 2892 | 0 | 86 | 30 | 1640 |
| WEAPONS CENTER | 459.324 | 276.079 | 245.008 | 173.281 | 570 | 4152 | 0 | 131 | 38 | 1602 |
| TOTALS | 2931.300 | 1420.035 | 1805.324 | 967.240 | 2206 | 24888 | 139 | 1786 | 519 | 12189 |

INSTALLATION: AEROSPACE MEDICAL RESEARCH LABORATORY PENSACOLA,FL.

C.O. CAPT. W. M. HOUK

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (AÇTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 3.683 | 3.461 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.705 | 0.717 |
| TOTAL ANNUAL LAB | 4.388 | 4.178 |
| | | |
| TOTAL INHOUSE | 4.195 | 4.088 |
| TOTAL INHOUSE RDT&E | 3.490 | 3.371 |
| ANNUAL OPERATING COST | 1.255 | 1.286 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 37 | 10 | 14 | 23 |
| CIVILIAN | 55 | 10 | 23 | 32 |
| TOTAL | 92 | 20 | 37 | 55 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 7 | 111.293 | 6.796 | 8.052 | 126.141 | 8.180 | 4.191 |

...MISSION

CONDUCT RESEARCH, DEVELOPMENT, TEST AND EVALUATION IN AVIATION MEDICINE AND ALLIED SCIENCES RELATED TO THE SAFETY AND PERFORMANCE OF NAVY AND MARINE CORPS PERSONNEL.

...CURRENT IMPORTANT PROGRAMS

AVIATION MEDICAL PERFORMANCE BASE STANDARDS
PHYSIOLOGICAL AND BEHAVIORAL EFFECTS NONIONIZING RADIATION.
HUMAN FACTORS DESIGN CRITERIA DEVELOPMENT.
DEVELOPMENT IN PERFORMANCE ENHANCEMENT IN NAVAL MOTION ENVIRONMENTS.
AVIATION VISUAL PERFORMANCE REQUIREMENTS AND CAPABILITIES.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MICROWAVE AND EXTREMELY LOW FREQUENCY NONIONIZING RADIATION FACILITY. SLOW ROTATION ROOM. CORIOLIS ACCELERATION PLATFORM. HUMAN DISORIENTATION DEVICE. STILL-WERNER CHAIR. OFF VERTICAL ROTATING CHAIR. ANACHOIC AND REVERBERANT CHAMBERS. AUTOMATED PULMONARY FUNCTION. TREADMILL. VECTOR AND ECHOCARDIOGRAPH. THERMOGRAPHIC IMAGING SYSTEM. 30 BINOCULAR EYE-TRACKER AND VISUAL STIMULATOR ELECTRON MICROSCOPE. VIVARIUM WITH OPERATING SUITE. EQUIPPED FOR HUMAN AND ANIMAL EXPERIMENTS IN UNUSUAL FORCE ATMOSPHERIC ACOUSTICAL ELECTROMAGNETIC ENVIRONMENTS. COMPLEX TASKS HUMAN PERFORMANCE MEASUREMENT SYSTEMS.

INSTALLATION: AIR DEVELOPMENT CENTER JOHNSVILLE,PA.

C.O. CAPT. J. B. ANDERSON TECH. DIR. MR. R. S. BUFFUM

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 171.072 | 193.004 |
| TOTAL PROCUREMENT | 67.767 | 63.491 |
| TOTAL O&M | 41.920 | 45.291 |
| TOTAL OTHER | 87.590 | 29.807 |
| TOTAL ANNUAL LAB | 318.849 | 331.093 |
| | | |
| TOTAL INHOUSE | 120.514 | 132.854 |
| TOTAL INHOUSE RDT&E | 80.647 | 84.233 |
| ANNUAL OPERATING COST | 54.965 | 66.906 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 254 | 5 | 63 | 191 |
| CIVILIAN | 2225 | 43 | 1805 | 920 |
| TOTAL | 2479 | 48 | 1868 | 1111 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 840 | 852.000 | 83.000 | 654.000 | 1589.000 | 87.900 | 52.000 |

...MISSION

TO BE THE PRINCIPAL NAVY RDT&E CENTER FOR NAVAL AIRCRAFT SYSTEMS LESS AIRCRAFT LAUNCHED WEAPON SYSTEMS

...CURRENT IMPORTANT PROGRAMS

TACTICAL SUPPORT CENTER
S-3A,F-14,F-18,VP PROGRAM
LIGHT AIRBORNE MULTI-PURPOSE SYSTEMS
V/STOL
J-TIDS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

AIRCRAFT SYSTEMS SIMULATION, AIRBORNE SEARCH & RESCUE, INERTIAL NAVIGATION TECHNOLOGY, AIR VEHICLE TECHNOLOGY (STRUCTURES, MATERIALS, FLIGHT DYNAMICS, PERFORMANCE, FLIGHT CONTROL) AIRBORNE ASW SYSTEMS, DEVELOP & INTEGRATION OF AIRBORNE SYSTEMS INCLUDING ELECTRONIC SURVEILLANCE & COUNTER MEASURES, COMMUNICATIONS, NAVIGATION INFORMATION PROCESSING & DISPLAY, ENVIRONMENTAL SENSING (ELECTROMAGNETIC/MAGNETIC, ACOUSTIC, ELECTRO-OPTIC, & PHOTOGRAPHIC), A/C SUPPORT SYSTEMS, A/C COST METHODOLOGY AND LOGISTICS, AEROSPACE MEDICINE AND AVIATION PHYSIOLOGY AND SUPPORT TO OTHER ACTIVITIES AS DIRECTED

INSTALLATION: BIODYNAMICS LABORATORY NEW ORLEANS LA

C.O. CAPT. L. E. WILLIAMS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 4.014 | 3.847 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.727 | 0.709 |
| TOTAL ANNUAL LAB | 4.741 | 4.556 |
| TOTAL INHOUSE | 3.885 | 3.619 |
| TOTAL INHOUSE RDT&E | 3.158 | 2.910 |
| ANNUAL OPERATING COST | 0.660 | 0.824 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 34 | 3 | 7 | 27 |
| CIVILIAN | 51 | 6 | 27 | 24 |
| TOTAL | 85 | 9 | 34 | 51 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 35.702 | 24.452 | 0.000 | 60.154 | 2.070 | 0.279 |

...MISSION

CONDUCT BIOMED RSCH ON EFFECTS OF MECH FORCES (MOTION, VIBRATION, IMPACT) ENCOUNTERED IN SHIPS AND AIRCRAFT BY NAVY PERSONNEL; ESTABLISH HUMAN TOLERANCE LIMITS FOR THESE FORCES; DEVELOP PREVENTIVE AND THERAPEUTIC METHODS TO PROTECT PERSONNEL FROM DELETERIOUS EFFECTS OF SUCH FORCES.

...CURRENT IMPORTANT PROGRAMS

LONG-TERM EFFECTS OF BIODYNAMIC STRESS EXPERIMENTS.
PHYSIOLOGICAL AND PERFORMANCE EFFECTS OF SHIP MOTION ON CREW MEMBERS.
DETERMINATION OF HUMAN DYNAMIC RESPONSE TO IMPACT ACCELERATION.
EFFECTS OF IMPACT ACCELERATION ON HUMAN NEUROPHYSIOLOGY.
DEVELOPMENT OF AND VALIDATION OF HUMAN ANTHROPOMORPHIC MANIKINS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

IMPACT FACILITY 1 MEGA N THRUST ACCELERATOR 213 M ENVIRONMENTALLY ENCLOSED TRACK. 17.8K N THRUST VERTICAL ACCELERATOR. XRAY CINEMATOGRAPHY ELECTRODYNAMIC MOTION EXCITORS. C210 SHAKER. SHIP MOTION GENERATOR. 22 CHANNEL INERTIA DATA ACQUISITION SYSTEM AND HIGH SPEED CAMERAS EQUIPPED FOR HUMAN AND ANIMAL EXPERIMENTS IN UNUSUAL FORCE ATMOSPHERIC ACOUSTICAL ELECTROMAGNETIC ENVIRONMENTS.

INSTALLATION: BIOSCIENCES LABORATORY OAKLAND,CA.

C.O. CDR. J. E. SIPPEL SCI. DIR. DR. D. KINGSBURY

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 2.900 | 2.830 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.309 | 0.282 |
| TOTAL ANNUAL LAB | 3.209 | 3.112 |
| TOTAL INHOUSE | 3.209 | 3.112 |
| TOTAL INHOUSE RDT&E | 2.900 | 2.830 |
| ANNUAL OPERATING COST | 0.779 | 1.089 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 9 | 4 | 5 | 4 |
| CIVILIAN | 6 | 0 | 0 | 6 |
| TOTAL | 15 | 4 | 5 | 10 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5 | 77.625 | 8.731 | 34.646 | 121.002 | 1.000 | 5.521 |

...MISSION

THE MISSION OF THE BIOSCIENCES LABORATORY IS TO CONDUCT RESEARCH AND DEVELOPMENT IN THE BIOSCIENCES RELATED TO THE NEEDS OF THE NAVAL ESTABLISHMENT.

...CURRENT IMPORTANT PROGRAMS

IMMUNE MECHANISMS OF INFECTIOUS DISEASES
RAPID DETECTION OF MICROORGANISMS
RECOMBINANT DNA TECHNOLOGY
TOXIC EFFECTS OF ORGANOMETAL COMPOUNDS IN THE MARINE ENVIRONMENT
TOXIC PROPERTIES OF NAVY RELEVANT CHEMICALS AND WASTES

...FUNCTIONS/EQUIPMENT/CAPABILITIES

EQUIPMENT INCLUDES CLASS III CONTAINMENT FACILITIES FOR HANDLING PATHOGENIC VIRUS AND BACTERIA, CONTINUOUS FLOW LIQUID WASTE DECONTAMINATION UNIT, PROCESS AIR DECONTAMINATION SYSTEM, ELECTRON SPIN RESONANCE AND NUCLEAR MAGNETIC RESONANCE SPECTROMETERS, ZILOG COMPUTER SYSTEM, SPECTROPHOTOMETERS, SPECTROFLUOROMETER AND SCANNING ELECTRON MICROSCOPES. THE EQUIPMENT IS CONTINUOUSLY BEING MODIFIED AND EXPANDED ACCORDING TO CURRENT PROJECTS. NBL IS A CONTRACT BASIC RESEARCH LAB WITH THE UCB; MOST SCIENTIFIC & TEC PERSONNEL ARE UCB EMPLOYEES.

INSTALLATION: CIVIL ENGINEERING LABORATORY PORT HUENEME, CA.

C.O. CAPT. NORMAN D. FALK TECH. DIR. DR. DONALD L. BIRKIMER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 32.741 | 36.390 |
| TOTAL PROCUREMENT | 0.448 | 0.310 |
| TOTAL O&M | 3.134 | 2.760 |
| TOTAL OTHER | 2.735 | 0.850 |
| TOTAL ANNUAL LAB | 39.058 | 40.310 |
| TOTAL INHOUSE | 21.108 | 21.849 |
| TOTAL INHOUSE RDT&E | 17.047 | 18.923 |
| ANNUAL OPERATING COST | 5.641 | 5.705 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 16 | 0 | 7 | 9 |
| CIVILIAN | 845 | 27 | 153 | 192 |
| TOTAL | 861 | 27 | 160 | 201 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 82 | 112.965 | 77.463 | 16.493 | 206.921 | 7.300 | 4.853 |

...MISSION

MISSION OF LABORATORY IS TO BE THE PRINCIPAL RDT AND E CENTER FOR NAVY SHORE FACILITIES, FIXED SURFACE AND SUBSURFACE OCEAN FACILITIES AND FOR THE NAVY AND MARINE CORPS CONSTRUCTION FORCES.

...CURRENT IMPORTANT PROGRAMS

NAVY SHORE FACILITIES SUPPORT. NAVY SEAFLOOR INSTALLATIONS, AMPHIBIOUS AND ADVANCED BASE TECHNOLOGY. ENVIRONMENTAL PROTECTION. ORGANIC MATERIALS. ENERGY TECHNOLOGY. DEEP OCEAN TECHNOLOGY. OFFSHORE BULK FUEL TRANSFER. INDEPENDENT EXPLORATORY DEVELOPMENT. INDEPENDENT RESEARCH. CONTAINER OFF-LOADING TRANSFER SYSTEM (COTS). MARINE CORPS. ARMY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

PRESSURE VESSEL FACILITY WITH 9, 18, 34, 72, INCH VESSELS SIMULATION PRESSURES TO OCEAN DEPTHS OF 20,000 FEET. DIVING LOCKER AND EQUIPMENT FOR 10 DIVERS. SEA FLOOR SOILS LAB. ENERGY TEST BED. CLASS G PHOTO LAB. PHYSICAL SECURITY LABS. CHEMISTRY LAB. INSTRUMENTATION LAB. WARPING TUG ELECTROMAGNETIC FACILITY. CORROSION AND METALURGICAL LABS. ENVIRONMENTAL RESEARCH LAB. CDC 8090 TERMINAL WITH HIGH SPEED READER AND LINE PRINTER. DIGITAL MAG TAPE. PEN PLOTTER. CURRENT SESOR LAB. ENERGY MONITORING CAPABILITY. PROTOTYPE MACHINE, WELDING, CARPENTER, AND RIGGING SHOPS. SHALLOW OCEAN SIMULATION FACILITY. MATERIAL TESTING LAB. ELECTRICAL SYSTEMS LAB. CONCRETE MIXING LAB. AGGREGATE PROCESSING LAB. DATA PROCESSING CENTER.

INSTALLATION: CLOTHING & TEXTILE RESEARCH FACILITY NATICK,MA.

C.O. CDR. JAMES C. ROBERTSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 2.655 | 3.116 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 1.253 | 1.881 |
| TOTAL OTHER | 0.056 | 0.290 |
| TOTAL ANNUAL LAB | 3.964 | 4.787 |
| | | |
| TOTAL INHOUSE | 3.659 | 3.788 |
| TOTAL INHOUSE RDT&E | 2.355 | 2.117 |
| ANNUAL OPERATING COST | 0.155 | 0.126 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 1 | 0 | 1 | 0 |
| CIVILIAN | 56 | 1 | 36 | 20 |
| TOTAL | 57 | 1 | 37 | 20 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 9.160 | 10.000 | 3.600 | 22.760 | 0.865 | 0.746 |

...MISSION

CONDUCT RESEARCH DEVELOPMENT TEST & EVALUATION & PROVIDE ENGINEERING SUPPORT IN CLOTHING TEXTILES & RELATED FIELDS ASSOCIATED WITH SERVICE CLOTHING & ENVIRONMENTAL PROTECTIVE CLOTHING.

...CURRENT IMPORTANT PROGRAMS

BATTLE DRESS CLOTHING
MATERIALS INVESTIGATIONS TO MEET NAVY CLOTHING REQUIREMENTS
PROTECTIVE CLOTHING FOR HAZARDOUS ENVIRONMENTS
LIFE SUPPORT SYSTEMS FOR PROTECTIVE CLOTHING
OCCUPATIONAL & SAFETY FOOTWEAR.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

HYDRO-ENVIRONMENT TEMPERATURE LAB,AIR CHAMBER-MARINE TANK REPRODUCES AIR-SEA TEMP CONDITIONS FOR WATER IMMERSION PHYSIOLOGY & BUOYANCY TESTS
ENVIRONMENTAL TEST CHAMBER FOR EVALUATING PROTECTIVE CLOTHING UNDER WORK STRESS & EXTREME TEMPERATURES.
INSTRUMENTED THERMAL MANIKIN FOR DETERMINING THERMAL INSULATION OF CLOTHING IN WET & DRY ENVIRONMENTS.
THERMAL FLAMMABILITY APPARATUS FOR CONDUCTION FLAME RETARDANCY.
FLAMMABILITY & HEAT RESISTANCE MATERIAL TESTING.
CHEMICAL & PHYSICAL TESTING EQUIPMENT FOR CONDUCTING RDT&E ON FABRICS, YARNS,FIBERS,LEATHER,PLASTICS,RUBBER,DYES,& FINISHES.
SEWING MACHINES & PATTERN DRAFTING FOR DEVELOPING GARMENTS.

INSTALLATION: COASTAL SYSTEMS CENTER PANAMA CITY,FL.

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C.O. CAPT. C. C. KING TECH. DIR. MR. G. C. DILWORTH

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 45.215 | 52.152 |
| TOTAL PROCUREMENT | 18.192 | 18.350 |
| TOTAL O&M | 9.149 | 10.000 |
| TOTAL OTHER | 8.171 | 7.415 |
| TOTAL ANNUAL LAB | 80.727 | 87.917 |
| TOTAL INHOUSE | 40.132 | 49.987 |
| TOTAL INHOUSE RDT&E | 24.846 | 29.322 |
| ANNUAL OPERATING COST | 13.607 | 20.577 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 116 | 0 | 13 | 103 |
| CIVILIAN | 647 | 27 | 364 | 283 |
| TOTAL | 763 | 27 | 877 | 386 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 648 | 342.248 | 47.291 | 363.488 | 753.027 | 47.942 | 22.481 |

...MISSION

TO BE THE PRINCIPAL NAVY RDT&E CENTER FOR MINE AND UNDERSEA COUNTERMEASURES, SPECIAL WARFARE, AMPHIBIOUS WARFARE, DIVING AND OTHER NAVAL MISSIONS THAT TAKE PLACE PRIMARILY IN THE COASTAL REGIONS.

...CURRENT IMPORTANT PROGRAMS

MINE AND UNDERSEA COUNTERMEASURES
TORPEDO AND SONAR COUNTERMEASURES
SHIP/AIRBORNE MINE COUNTERMEASURES COMBAT SYSTEM INTEGRATION
DIVING, SALVAGE, AND SPECIAL WARFARE
AMPHIBIOUS WARFARE

...FUNCTIONS/EQUIPMENT/CAPABILITIES

FACILITIES INCLUDE- OCEAN SIMULATION FAC TO 2250' DEPTH. HYDROSPACE LAB. SWIMMER/DIVER R&D FAC. GAS ANALYSIS LAB. SONAR TEST BED. MAGNETIC TARGET DETECTION & CLASSIFICATION RANGE. MAGNETIC LAB. OPTICAL POSITIONING SYS. TWO UNMANNED OFFSHORE SENSOR/INSTRUMENTATION PLATFORMS. CALIBRATION AND STANDARDS FAC. MECHANICAL CALIBRATION LAB. CABLE TEST FAC. ACOUSTIC TEST FAC. TRANSDUCER LAB. PRECISION ACOUSTIC TANK. ACOUSTIC ANAL FAC. SYS DEV AND TEST FAC. LASER LAB. ELECTRONIC TRACKING RANGE, PORTABLE TRACKING & POST RUN ANALYSIS SYS. COUNTERMEASURES EVALUATOR IN REAL-TIME SIMULATION BURROUGHS 6810 DIGITAL COMPUTER AND ASSOCIATED DATA COMMUNICATIONS SYS. ENVIRONMENTAL MONITORING FAC. SONAR PROCESSING FAC. INTERACTIVE GRAPHICS SYS. PIER SPACE & BOATS TO INCLUDE RESEARCH VESSELS ATHENA I&II, MSO-448 USS FIDELITY. INDUSTRIAL SHOPS. HELIPORT COMPLEX WITH 2 RH53D & 2 UH1E.

INSTALLATION: DAVID W. TAYLOR SHIP R&D CENTER BETHESDA,MD.

C.O. CAPT. B. F. TIBBITTS TECH. DIR. DR. A. POWELL

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 164.647 | 184.660 |
| TOTAL PROCUREMENT | 18.997 | 15.456 |
| TOTAL O&M | 31.965 | 26.912 |
| TOTAL OTHER | 9.447 | 14.754 |
| TOTAL ANNUAL LAB | 225.056 | 241.782 |
| | | |
| TOTAL INHOUSE | 113.757 | 126.692 |
| TOTAL INHOUSE RDT&E | 87.503 | 98.845 |
| ANNUAL OPERATING COST | 47.358 | 47.283 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 76 | 1 | 23 | 53 |
| CIVILIAN | 2478 | 118 | 1206 | 1272 |
| TOTAL | 2554 | 119 | 1229 | 1325 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 325 | 1705.165 | 99.405 | 328.172 | 2132.742 | 73.770 | 88.446 |

...MISSION

TO BE THE PRINCIPAL NAVY RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDT&E) CENTER FOR NAVAL VEHICLES AND LOGISTICS AND TO PROVIDE RDT&E SUPPORT TO THE U.S. MARITIME ADMINISTRATION AND THE MARITIME INDUSTRY.

...CURRENT IMPORTANT PROGRAMS

SURFACE SHIP AND SUBMARINE SILENCING (ACOUSTIC/NON-ACOUSTIC/MACHINERY), SURFACE SHIP SURVIVABILITY AND TOPSIDE STRUCTURES,
PROPULSOR DEVELOPMENT (HYDRODYNAMICS/STRUCTURES/ACOUSTICS), SUBMARINE PRESSURE HULL AND NON-PRESSURE HULL (STRUCTURES/MATERIALS),
AERODYNAMICS (JET-VANE YAW CONTROL/X-WING ROTOR SYS/CIRCULATION CONTROL)

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MAJOR EQUIPMENT/FACILITY CAPABILITIES: SHALLOW AND DEEP WATER TOWING BASINS, MANEUVERING AND SEAKEEPING BASIN, WIND TUNNELS, ANECHOIC FLOW FACILITY, WATER TUNNELS, STRUCTURAL EVALUATION FACILITY, UNDERWATER EXPLOSIONS LABORATORY BARGE, PRESSURE TANKS, SUBMARINE INTERNAL FLUID DYNAMICS FACILITY, METALLURGICAL CHARACTERIZATION AND EVALUATION FACILITY, WELDING DEVELOPMENT LABORATORY, ENVIRONMENTAL PROTECTION LABORATORY, PAINT DEVELOPMENT LABORATORY, MACHINERY DEVELOPMENT LABORATORY, FUELS LABORATORY, FABRICATION TECHNOLOGY LABORATORY, SHOCK AND VIBRATION FACILITY, ELECTRIC PROPULSION TEST CRAFT, DEEP OCEAN TECHNOLOGY HIGH-PRESSURE TEST FACILITY, TURBO-ELECTRIC PROPULSION LABORATORY, NOISE MEASUREMENT FACILITY.

INSTALLATION: DENTAL RESEARCH INSTITUTE. GREAT LAKES, IL.

C.O. CAPT. G. E. CLARK SCI. DIR. DR. I. R. SHKLAIR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 0.874 | 0.924 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.859 | 0.848 |
| TOTAL ANNUAL LAB | 1.733 | 1.772 |
| TOTAL INHOUSE | 1.698 | 1.736 |
| TOTAL INHOUSE RDT&E | 0.839 | 0.888 |
| ANNUAL OPERATING COST | 0.507 | 0.601 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 29 | 8 | 13 | 16 |
| CIVILIAN | 15 | 4 | 6 | 9 |
| TOTAL | 44 | 12 | 19 | 25 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 21.264 | 6.001 | 9.318 | 36.583 | 0.000 | 1.032 |

...MISSION
TO CONDUCT RESEARCH&DEVELOPMENT TEST AND EVALUATION IN DENTAL AND ALLIED SCIENCES WITH PARTICULAR EMPHASIS ON PROBLEMS OF DENTAL AND ORAL HEALTH IN NAVY AND MARINE CORPS POPULATIONS AND ON PROBLEMS OF FLEET AND FIELD DENTISTRY.

...CURRENT IMPORTANT PROGRAMS
THE PATHOGENESIS OF ORAL DISEASES.
DEVELOPMENT OF METHODS FOR PREVENTING ORAL DISEASES & DENTAL EMERGENCY.
COMPUTER ASSISTED DIAGNOSIS OF DENTAL EMERGENCIES.
DESIGN AND DEVELOPMENT OF AN ORAL EPIDEMIOLOGY INFO.SYSTEMS
DEVELOPMENT OF A MARINE CORPS EXPEDITIONARY DENTAL SHELTER.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
AMINO ACID ANALYZER/ATOMIC ASORPTION UNIT/LIQUID SCINTILLATION COUNTER/MIN COMPUTER/GAS CHROMATOGRAPH UNIT/PHOTOMICROSCOPE/FIVE DENTAL UNITS/SIX DENTAL CHAIRS/ELECTRON MICROSCOPE/CRYOMICROTOME/DIAZO PROCESSOR/SPECTROPHOTOMETERS/ORAL SURGERY CHAIR/THERMAL BALANCE/VIVARIUM/ANIMAL SURGERY ROOM/XRAY EQUIPMENT/RPM INSTRUMENTS/SOUND METERS/ANAEROBIC CHAMBER/SHAKERS/INCUBATORS/CENTRIFUGES/BIOLOGICAL SAFETY CABINET/FRACTIONATORS/RECORDERS/FIELD DENTAL EQUIPMENT/PROTOTYPE SHOPS/PROTOTYPE MARINE CORPS EXPEDITIONARY DENTAL SHELTER/PHOTO LAB/OSCILLISCOPE/EQUIPMENT REPAIR SHOP/TISSUE CULTURE.

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INSTALLATION: ENVIRONMENTAL PREDICTION RESEARCH FACILITY MONTEREY,CA.

CO. CAPT. K. L. VAN SICKLE DIR. OF RSCH. DR. A. WEINSTEIN

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 5.177 | 5.639 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.618 | 0.462 |
| TOTAL OTHER | 0.486 | 0.429 |
| TOTAL ANNUAL LAB | 6.276 | 6.530 |
| TOTAL INHOUSE | 2.849 | 2.987 |
| TOTAL INHOUSE RDT&E | 2.265 | 2.359 |
| ANNUAL OPERATING COST | 1.174 | 1.083 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 14 | 2 | 5 | 9 |
| CIVILIAN | 32 | 8 | 27 | 5 |
| TOTAL | 46 | 10 | 32 | 14 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 5.446 | 14.040 | 5.098 | 24.584 | 0.000 | 1.355 |

...MISSION

CONDUCT RESEARCH & DEVELOPMENT DIRECTED TOWARD PROVIDING OBJECTIVE LOCAL REGIONAL AND GLOBAL ENVIRONMENTAL ANALYSIS & PREDICTION TECHNIQUES. PROVIDE PLANNING, MODELING & EVALUATION SERVICES TO DETERMINE THE EFFECT OF ENVIRONMENTAL ELEMENTS ON NAVAL WEAPONS SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

DEVELOP SYSTEM FOR PROCESS/DISPLAY OF ENVIRONMENTAL SATELLITE DATA
DEVELOP COMPUTER MODELS WHICH ANALYZE/ASSIMILATE ATMOSPHERIC DATA
DEVELOP TECHNIQUES PREDICT/DIAGNOSE ATMOS EFFECTS ON WEAPONS SYSTEMS
DEVELOP OBJECTIVE LOCAL/REGIONAL ATMOS ANALYSIS/PREDICTION TECHNIQUES
DEVELOP SYNOPTIC/SUBSYNOPTIC & MESOSCALE ATMOS PREDICTION MODELS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

CAPABILITY OF RECEIVING, ENHANCING AND ANALYZING REMOTEL SENSED ATMOS DATA.
CAPABILITY OF BUILDING, ANALYZING AND MODIFYING GLOBAL, REGIONAL AND LOCAL WEATHER MODELS
CAPABILITY TO DEVELOP ATMOS PREDICTION AIDS FOR USE BY NON-GRADUATE METEOROLOGICAL PERSONNEL
ECLIPSE S250 COMPUTER ACCESS TO CYBER 203 AND 175 COMPUTERS

INSTALLATION: HEALTH RESEARCH CENTER SAN DIEGO,CA.

C.O. CAPT. J. E. LANG CH. SCI. DR. L. C. JOHNSON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 3.239 | 2.876 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 1.005 | 1.011 |
| TOTAL ANNUAL LAB | 4.244 | 3.887 |
| | | |
| TOTAL INHOUSE | 3.563 | 3.256 |
| TOTAL INHOUSE RDT&E | 2.558 | 2.245 |
| ANNUAL OPERATING COST | 1.894 | 0.993 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 30 | 11 | 14 | 16 |
| CIVILIAN | 60 | 10 | 24 | 36 |
| TOTAL | 90 | 21 | 38 | 52 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 19.052 | 7.159 | 0.000 | 26.211 | 0.147 | 1.527 |

...MISSION

THE EFFECT OF BENZODIAZEPINES ON SLEEP BRAIN ACTIVITY AROUSAL THRESHOLD.
BEHAVIOURAL EFFECTS OF AND ADJUSTMENT TO COLD ENVIRONMENTS.
EPIDEMIOLOGY IN EMPLOYEES OF NWC CHINA LAKE.
EPIDEMIOLOGICAL ANALYSIS OF HLTH & SAFETY IN SELECT NAV OCCUP & ENVRNS.

...CURRENT IMPORTANT PROGRAMS

AN EXPLORATORY STUDY OF RECENT DISASTERS IN THE US NAVY.
BIOENERGETICS OF EXERCISE: SUPPLY/UTILIZATION CONTR MECH INVOLV GASTRO.
THE EFFECT OF PASSIVE HEATING AND NONAEROBIC EXERCISE ON HEAT TOLERANCE.
SOCIOCULTURAL INFLUENCES ON HEALTH AND CAREER OUTCOME FOR US NAVY PERS.
EVAL OF ENVIRONMENTAL AIRCRAFT AND INDIVID FACTORS AFFECT AVIATOR PERF.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

AGE SPECIFIC MORBIDITY AMONG NAVAL AVIATORS.
HUMAN PERFORMANCE EFFECT AND PHYSIOLOGICAL ADAPT DURING SUSTAINED OPS.
FEASIBILITY OF MEDICAL DATA AUTOMATION UNDER FIELD CONDITIONS.
DEVELOP OF STANDARDS FOR OBESITY & PHYSICAL FITNESS AMONG NAVAL PERS.
LONG TERM HEALTH EFFECTS AMONG NAVY DIVERS.
DEVELOP AND PILOT TESTING OF A NAVY OCCUP HEALTH INFO MONITORING SYSTEM.
EFFECTS OF ORG FACTORS ON HEALTH CARE DELIVERY AND UTIL IN NAVY HOSP.
DEVELOP AND EVAL OF IMPROVED METHODS FOR THE ID OF INFECT AGENTS OF MIL.

INSTALLATION: MEDICAL RESEARCH INSTITUTE BETHESDA MARYLAND

C.O. CAPT. L. SPHAR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 15.149 | 16.597 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.072 | 0.004 |
| TOTAL OTHER | 5.800 | 6.824 |
| TOTAL ANNUAL LAB | 20.521 | 22.925 |
| | | |
| TOTAL INHOUSE | 19.435 | 22.806 |
| TOTAL INHOUSE RDT&E | 14.088 | 16.490 |
| ANNUAL OPERATING COST | 7.648 | 8.878 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 245 | 62 | 78 | 167 |
| CIVILIAN | 171 | 41 | 86 | 85 |
| TOTAL | 416 | 103 | 164 | 252 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 4 | 159.933 | 11.720 | 47.210 | 218.863 | 7.059 | 12.678 |

...MISSION
CONDUCT BASIC & APPLIED RESEARCH & DEVELOPMENT CONCERNED WITH THE HEALTH SAFETY & EFFICIENCY OF NAVY AND MARINE CORPS PERSONNEL.

...CURRENT IMPORTANT PROGRAMS
COMBAT CARE TECHNOLOGY WOUND HEALING SHOCK TISSUE TRANSPLANTATION
MICROBIOLOGY VACCINE DEV RAPID DIAGNOSIS EPIDEMIOLOGY
HYPERBARIC MEDICINE PHYSIOLOGY TREATMENT SAFETY
ENVIRONMENTAL STRESS THERMAL ELECTROMAGNETIC TOXIC
BONE MARROW TRANSPLANTATION STEM CELLS GROWTH FACTORS

...FUNCTIONS/EQUIPMENT/CAPABILITIES
HYPERBARIC RESEARCH FACILITY WITH MAN-RATED HYPERBARIC CHAMBERS.
HUMAN PHYSIOLOGICAL & HEAT STRESS EQUIPMENT & FACILITIES.
HUMAN TISSUE PRESERVATION & STORAGE EQUIPMENT & FACILITIES.
BIOHAZARDOUS MATERIALS HANDLING LAB EQUIPMENT & FACILITIES.
TOXICOLOGY EVALUATION EQUIP & FACILITIES INCLUDE HYPERBARIC CHAMBERS
TRANSMISSION & SCANNING ELECTRON MICROSCOPES FLUORESCENT ANTIBODY CELL SORTER & COMPUTERS.
EXPERIMENTAL ANIMAL FACILITIES ANIMAL HOUSE & OPERATING ROOMS
LAB EQUIPMENT & FACILITIES FOR BASIC & APPLIED BIOCHEMICAL
MICROBIOLOGICAL & PSYCHOLOGICAL & TRANSPLANTATION STUDIES

INSTALLATION: MEDICAL RESEARCH UNIT NO.2 MANILA,PHILIPPINES

C.O. CAPT. W. H. SCHROEDER SCI. DIR. DR. J. H. CROSS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 2.221 | 2.881 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.890 | 0.957 |
| TOTAL ANNUAL LAB | 3.111 | 3.838 |
| | | |
| TOTAL INHOUSE | 3.111 | 3.838 |
| TOTAL INHOUSE RDT&E | 2.221 | 2.881 |
| ANNUAL OPERATING COST | 0.693 | 0.775 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 31 | 4 | 20 | 11 |
| CIVILIAN | 58 | 2 | 9 | 49 |
| TOTAL | 89 | 6 | 29 | 60 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 5.550 | 3.510 | 4.202 | 13.262 | 0.000 | 0.253 |

...MISSION

TO CONDUCT RESEARCH AND DEVELOPMENT ON INFECTIOUS DISEASES OF MILITARY IMPORTANCE THAT ARE ENDEMIC OR EPIDEMIC IN THE ASSIGNED GEOGRAPHIC AREAS TO PERFORM SUCH OTHER FUNCTIONS OR TASKS AS MAY BE DIRECTED BY CHIEF, BUREAU OF MEDICINE AND SURGERY.

...CURRENT IMPORTANT PROGRAMS

CONDUCTS RESEARCH ON TROPICAL COMMUNICABLE DISEASES TO INCLUDE MALARIA, AMEBIASIS, PARASITIC DISEASES,ARTHROPOD VECTOR DISEASES & DIARRHEA. EMPHASIS IS ON DIAGNOSIS,PREVENTION, AND TREATMENT OF TROPICAL INFECTIOUS DISEASES AND THEIR GEOGRAPHIC EPIDEMIOLOGY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

AUTOCLAVES;LAMINAR FLOW BIOLOGICAL SAFETY CABINETS;AIR AND CO2 INCUBATORS;FLUORESCENT AND COMPOUND MICROSCOPES;DISECTING MICROSCOPES;ZEISS PHOTOMICROSCOPE;SUPERSPEED- AND ULTRACENTRIFUGES;LIQUID SCINTILLATION COUNTER;COULTER COUNTER;ULTRAFLOW TEMPERATURE FREEZERS; SPECTROPHOTOMETERS;FRACTION COLLECTORS;ELISA READER;IBM 1130 COMPUTER; INSECTORY;ANIMAL PRODUCTION FACILITIES;CELL CULTURE FACILITIES;FACILITIES IN INDONESIA INCLUDE 10000 SQUARE FEET FOR ALL SPACES.

INSTALLATION: MEDICAL RESEARCH UNIT NO.3 CAIRO,EGYPT

C.O. CAPT. CRAIG K. WALLACE SCI. DIR. DR. AFTAB A. ANSARI

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 3.685 | 4.246 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.124 | 0.118 |
| TOTAL OTHER | 0.909 | 0.960 |
| TOTAL ANNUAL LAB | 4.718 | 5.324 |
| | | |
| TOTAL INHOUSE | 4.718 | 5.324 |
| TOTAL INHOUSE RDT&E | 3.685 | 4.246 |
| ANNUAL OPERATING COST | 0.970 | 0.980 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 29 | 12 | 13 | 16 |
| CIVILIAN | 202 | 17 | 41 | 161 |
| TOTAL | 231 | 29 | 54 | 177 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5 | 89.472 | 8.962 | 61.072 | 159.506 | 9.054 | 1.020 |

...MISSION

TO CONDUCT RESEARCH, DEVELOPMENT, TEST AND EVALUATION RELATING TO THE HEALTH, SAFETY, AND READINESS OF NAVAL PERSONNEL ASSIGNED TO SOUTHWEST ASIA AND AFRICA, AND TO PERFORM SUCH OTHER FUNCTIONS AS MAY BE DIRECTED BY HIGHER AUTHORITY

...CURRENT IMPORTANT PROGRAMS

EPIDEMIOLOGY AND PREVALENCE OF MILITARY RELEVANT INFECTIOUS DISEASES IN SOUTHWEST ASIA AND AFRICA

THERAPY OF INFECTIOUS DISEASE IN SOUTHWEST ASIA

RAPID AND EARLY DIAGNOSIS OF INFECTIOUS DISEASES OF MILITARY IMPORTANCE IN SOUTHWEST ASIA

...FUNCTIONS/EQUIPMENT/CAPABILITIES

LECTURESCOPE MODEL LS-2 WITH VERTICAL ILLUMINATOR,OILFIRED PORTABLE HOT HIGH PRESSURE CLEANER, ROTARY MICROTOME,AUTOMATIC MICROTOME KNIFE SHARPENER, LOW DOSE ANIMAL IRRADIATOR, FREEZING CHAMBER, BIOGARD HOODS, ABSORBANCE MONITOR WITH STAND AND FLOW CELL,REFRIGERATED FRACTION COLLECTOR SYSTEM WITH SAMPLE PROGRAMMER,LABCONCO GLOVE BOX, INCUBATOR SINGLE CHAMBER, ULTRACENTRIFUGE, MICROSCOPE B&L COMPOUND, MICROSCOPE BALPAN, TRINOCULAR MICROSCOPE, MICROSCOPE AO COMPOUND, AMSCO STERILIZER, DAMON/IEC CENTRIFUGE WITH SWINGING BUCKET HEAD, ULTRA LOW REVCOS, FLUORESCENT MICROSCOPES EQUIPPED FOR EPIFLUORESCENCE, DENTAL UNIT, CAVITRON, HIGH PRESSURE LIQUID CHROMATOGRAPH, PROGRAMMABLE CONTROLLER, ELISA READER, ANAEROBIC CHAMBER, LIQUID SCINTILLATION AND GAMMA COUNTERS, ANIMAL PRODUCTION FACILITY, PATIENT WARDS, PUBLIC WORKS FACILITY.

√ INSTALLATION: OCEAN R & D ACTIVITY BAY ST.LOUIS,MS.

C.O. CAPT. G. T. PHELPS TECH. DIR. DR. J. E. ANDREWS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 46.252 | 40.789 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.633 | 0.591 |
| TOTAL OTHER | 1.513 | 1.423 |
| TOTAL ANNUAL LAB | 48.398 | 42.803 |
| TOTAL INHOUSE | 20.308 | 18.034 |
| TOTAL INHOUSE RDT&E | 18.341 | 16.189 |
| ANNUAL OPERATING COST | 6.388 | 7.714 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 16 | 1 | 11 | 5 |
| CIVILIAN | 312 | 76 | 201 | 111 |
| TOTAL | 328 | 77 | 212 | 116 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5 | 51.002 | 23.881 | 83.069 | 157.952 | 10.048 | 11.000 |

...MISSION

TO CARRY OUT A BROAD BASED RDT&E PROGRAM IN OCEAN SCIENCE AND TECHNOLOGY WITH EMPHASIS ON UNDERSTANDING OCEAN PROCESSES THROUGH MEASUREMENT AND ANALYSIS, AND THE EFFECTS OF THIS OCEAN ENVIRONMENT ON NAVY SYSTEMS AND OPERATIONS.

...CURRENT IMPORTANT PROGRAMS

VLF/LOW/MID/HIGH FREQUENCY ACOUSTIC R&D SUPPORTS SURV/TACT WEAPONS SYS DEVELOP/PERFORM. ARCTIC R&D SUPPORTS TORPEDOE/SUB SONAR DEVELOP/PERFORM. SEA STATE/WAVE R&D SUPPORTS HULL DESIGN & WAVE FORECASTING. REMOTE SENSING OCEANOGRAPHY/NUMERICAL MODELING SUPPORT OCEAN FORECASTING. MC&G R&D SUPPORT NAVY/MARINE CORPS/DMA MC&G PRODUCTS DEVELOPMENT.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

WAVE/CURRENT SIMULATION FACILITY, INTERACTIVE DIGITAL SATELLITE IMAGE PROCESSING SYSTEM, REAL TIME SATELLITE DATA RECEIVING CAPABILITY, SEDIMENT PHYSICS/GEOTECHNICAL LABORATORY, VEKA AND VEDABS ACOUSTIC ARRAYS, X-RAY FLUORESCENT, TRANSMISSION/SCANNING MICROSCOPE AND PATTERN ANALYSIS LABORATORY.

INSTALLATION: OCEAN SYSTEMS CENTER SAN DIEGO,CA.

C.O. CAPT. J. M. PATTON TECH. DIR. MR. R. M HILLYE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 243.232 | 263.500 |
| TOTAL PROCUREMENT | 57.485 | 47.400 |
| TOTAL O&M | 65.876 | 65.000 |
| TOTAL OTHER | 24.907 | 29.475 |
| TOTAL ANNUAL LAB | 391.500 | 405.375 |
| TOTAL INHOUSE | 182.198 | 189.975 |
| TOTAL INHOUSE RDT&E | 121.043 | 129.800 |
| ANNUAL OPERATING COST | 63.329 | 66.058 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 269 | 2 | 49 | 220 |
| CIVILIAN | 2582 | 181 | 1382 | 1200 |
| TOTAL | 2851 | 183 | 1431 | 1420 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 2719 | 1280.660 | 201.210 | 210.070 | 1691.940 | 53.504 | 64.599 |

...MISSION
TO BE THE PRINCIPAL NAVY RESEARCH, DEVELOPMENT, TEST AND EVALUATION CENTER FOR COMMAND CONTROL, COMMUNICATIONS, OCEAN SURVEILLANCE, SURFACE- AND AIR-LAUNCHED UNDERSEA WEAPONS SYSTEMS, AND SUBMARINE ARCTIC WARFARE.

...CURRENT IMPORTANT PROGRAMS
OCEAN SURVEILLANCE SYS WITH SOSUS UPDATE AND MULTI-SENSOR INTEGRATION, COMMAND CONTROL AND COMMUNICATIONS SYS ARCHITECTURE AND ENGINEERING, ADVANCED SURFACE AND AIR LAUNCHED UNDERSEA WEAPONS AND SURFACE ASW SYS, TECHNOLOGY DEVELOPMENTS SUCH AS ADV MARINE BIO SYS, ARCTIC SUB OPS, OCEAN ENGINEERING, ELECTRONIC WARFARE AND ARTIFICIAL INTELLIGENCE.

...FUNCTIONS/EQUIPMENT/CAPABILITIES
CENTER FACILITIES INCLUDE ARCTIC RESEARCH FACILITY; C3 SITE, INCLUDING TACTICAL FLAG COMMAND CENTER (TFCC) AND ADVANCED COMMAND CONTROL ARCHITECTURE TEST BED (ACCAT); OCEAN SURVEILLANCE FACILITY; ACOUSTIC RESEARCH CENTER (ARC) WITH SATELLITE DATA LINKS; INTEGRATED UNDERSEA SURVEILLANCE SYSTEM (IUSS) FACILITY; MICROWAVE AND MILLIMETER WAVE ANTENNA PATTERN RANGE COMPLEX; OCEANOGRAPHIC RESEARCH TOWER; STABLE SEMI-SUBMERGED PLATFORM; UNMANNED TETHERED VEHICLES INCL CURV III, SCAT, AND SNOOPY; USS DOLPHIN, EXPERIMENTAL SUB· TRANSDUCER EVALUATION CENTER; MICRO-ELECTRONICS LAB COMPLEX; SIMULATION AND REAL-TIME COMPUTER FACILITIES FOR DEVELOPMENT OF OCEAN SURVEILLANCE AND ASW SYSTEMS; SHIP MOTION SIMULATOR AND A BIO-SCIENCE FACILITY ENGAGED IN RESEARCH, TRAINING AND HANDLING OF MARINE MAMMALS.

INSTALLATION: PERSONNEL RESEARCH & DEVELOPMENT CENTER SAN DIEGO,CA.

C.O. CAPT. J. W. RENARD TECH. DIR. DR. J. W. TWEEDALE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 17.604 | 15.253 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 8.157 | 3.215 |
| TOTAL OTHER | 2.847 | 3.025 |
| TOTAL ANNUAL LAB | 23.608 | 21.493 |
| TOTAL INHOUSE | 15.941 | 16.790 |
| TOTAL INHOUSE RDT&E | 11.696 | 11.465 |
| ANNUAL OPERATING COST | 4.192 | 5.224 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 34 | 4 | 17 | 17 |
| CIVILIAN | 293 | 81 | 208 | 85 |
| TOTAL | 327 | 85 | 225 | 102 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1 | 64.492 | 7.137 | 5.280 | 76.909 | 0.545 | 7.840 |

...MISSION

PRINCIPAL NAVY RDT&E CENTER FOR MANPOWER,PERSONNEL,EDUCATION,TRAINING AND HUMAN FACTORS AND FOR PROVIDING TECHNICAL SUPPORT TO THE CHIEF OF NAVAL OPERATIONS IN THESE AREAS.

...CURRENT IMPORTANT PROGRAMS

MANPOWER MANAGEMENT
EDUCATION AND TRAINING
PERSONNEL ADMINISTRATION
ORGANIZATIONAL MANAGEMENT
HUMAN PERFORMANCE

...FUNCTIONS/EQUIPMENT/CAPABILITIES

IBM 4341 COMPUTER SYSTEM WITH COMMUNICATIONS CAPABILITY TO OTHER COMPUTERS,VAX 11/780 WITH ARPANET ACCESS WHICH SUPPORTS THE NAVY LABORATORY COMPUTER NETWORK,PDP 11/45,BIOTECHNOLOGY DATA ACQUISITION SYSTEMS,VARIOUS CRT AND PRINTING DEVICES INTERFACING WITH THE NAVAL OCEAN SYSTEMS CENTER UNIVAC 1100/2 COMPUTER.

INSTALLATION: RESEARCH LABORATORY WASHINGTON,D.C.

C.O. CAPT. J.A. MCMORRIS II DIR. OF RSCH. DR. T. COFFEY

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 802.650 | 824.700 |
| TOTAL PROCUREMENT | 7.916 | 8.204 |
| TOTAL O&M | 9.333 | 8.145 |
| TOTAL OTHER | 21.150 | 18.404 |
| TOTAL ANNUAL LAB | 841.049 | 859.453 |
| TOTAL INHOUSE | 185.474 | 182.323 |
| TOTAL INHOUSE RDT&E | 163.130 | 163.030 |
| ANNUAL OPERATING COST | 72.900 | 81.632 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 137 | 2 | 40 | 97 |
| CIVILIAN | 3090 | 664 | 1505 | 1585 |
| TOTAL | 3227 | 666 | 1545 | 1682 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1072 | 2348.281 | 192.677 | 481.382 | 3022.340 | 98.500 | 118.917 |

...MISSION

TO CONDUCT A BROADLY BASED MULTIDISCIPLINARY PROGRAM OF SCIENTIFIC RESEARCH AND ADVANCED TECHNOLOGICAL DEVELOPMENT DIRECTED TOWARD NEW AND IMPROVED MATERIALS, EQUIPMENT, TECHNIQUES, SYSTEMS, AND RELATED OPERATIONAL PROCEDURES FOR THE NAVY.

...CURRENT IMPORTANT PROGRAMS

DIRECTED ENERGY DEVICES
ADVANCED ECM AND DECOYS FOR NAVY EW SYSTEMS
ADVANCED ACOUSTIC AND NON-ACOUSTIC SUBMARINE DETECTION PROGRAMS
SATELLITE PROGRAMS
ADVANCED HIGH PERFORMANCE MATERIALS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

PRINCIPAL RESEARCH AND DEVELOPMENT LABORATORY OF THE NAVY. PRIMARY AREAS ARE MATERIALS SCIENCE AND TECHNOLOGY, SPACE SCIENCE AND TECHNOLOGY, RADAR, ELECTRONIC WARFARE, LASER TECHNOLOGY, OPTICS, OPTICAL WARFARE, ELECTRONIC DEVICES, PLASMA AND RADIATION PHYSICS, INTELLIGENCE SUPPORT, UNDERSEA SURVEILLANCE. MAJOR FACILITIES INCLUDE ACOUSTIC STANDARD AND CALIBRATION FACILITIES, HIGH LEVEL RADIATION LABORATORY, ENCLOSED 11,500 CU FT FIRE TEST FACILITY, DIVERSE HIGH ENERGY LASERS, 200 KILOGAUSS HIGH FIELD MAGNET FACILITY, SPACE SIMULATION FACILITIES, AND ELECTRONIC WARFARE CENTRAL TARGET SIMULATOR.

INSTALLATION: SURFACE WEAPONS CENTER SILVER SPRING,MD.

C.O. CAPT. J. R. WILLIAMS TECH. DIR. DR. L. L. HILL

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1988<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 279.827 | 279.128 |
| TOTAL PROCUREMENT | 114.258 | 70.905 |
| TOTAL O&M | 64.485 | 56.476 |
| TOTAL OTHER | 49.854 | 84.854 |
| TOTAL ANNUAL LAB | 507.924 | 440.858 |
| | | |
| TOTAL INHOUSE | 216.508 | 264.698 |
| TOTAL INHOUSE RDT&E | 127.819 | 141.706 |
| ANNUAL OPERATING COST | 104.668 | 124.289 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 103 | 0 | 85 | 68 |
| CIVILIAN | 5089 | 241 | 2807 | 2782 |
| TOTAL | 5192 | 241 | 2842 | 2850 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5847 | 1656.078 | 180.751 | 1306.003 | 8142.832 | 105.975 | 150.289 |

...MISSION

THE PRINCIPAL NAVY RESEARCH, DEVELOPMENT, TEST AND EVALUATION CENTER FOR SURFACE SHIP WEAPONS SYSTEMS, ORDNANCE, MINES AND STRATEGIC SYSTEMS SUPPORT

...CURRENT IMPORTANT PROGRAMS

STRATEGIC SYSTEMS-TRIDENT, POSEIDON, MK500,MISSILE MATERIELS,TARGETING.
COMBAT-SYSTEMS-AEGIS,DDG-51, CV/CVN, CGN-38, DDG-993, DD-963,
WEAPON SYSTEMS-TOMAHAWK, SM-2, GUIDED PROJECTILE, HI POWER RADIATION.
UNDERWATER SYSTEMS-CAPTOR, QUICKSTRIKE, MINES,MK-48(ADCAP), WARHEADS.
ELECTRONIC SYSTEMS-SLQ-32, SLQ-17, AN/SPY-1, NUCLEAR WPNS EFFECTS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

FACILITIES INCLUDE WIND TUNNELS UP TO MACH 18, 1.75 MILLION GAL. HYDROBALLISTIC TANK, MAGNETIC SILENCING FACILITY, PBM DISKPAC PRODUCTION FACILITY, FACILITIES FOR ASSURANCE OF COMPUTER PROGRAMS FOR STRATEGIC AND TACTICAL MISSILES, INTELLIGENCE PROCESSING SYS, GUN AND MISSILE RANGE INCLUDING LAND-BASED DEVELOPMENT SITES FOR WEAPON CONTROL SYSTEMS. ELECTROMAGNETIC EFFECTS FACILITIES FOR NUCLEAR AND NON-NUCLEAR EFFECTS. FACILITIES FOR WARHEAD CHARACTERIZATION AND DAMAGE TO TARGETS, DEV AND TEST FACILITIES FOR LASER AND ELECTRO-OPTICS SUBSYSTEMS, DEEP WATER OFFSHORE FACILITIES FOR MINE SYS,MOBILE TACTICAL WAR GAMES FACILITY, EXPLOSIVES DEV FACILITIES, EXTENSIVE SCIENTIFIC COMPUTER FACILITY,FUZES, EXPLOSIVES, MATERIALS AND MARINE CORPS SUPPORT FACILITIES.

INSTALLATION: UNDERSEA RANGES DEPARTMENT NEWPORT,RI.

C.O.CAPT. J. W. AILES,IV TECH. DIR. MR. EARL MESSERE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 87.259 | 86.814 |
| TOTAL PROCUREMENT | 0.742 | 0.637 |
| TOTAL O&M | 10.950 | 11.890 |
| TOTAL OTHER | 1.603 | 1.115 |
| TOTAL ANNUAL LAB | 50.554 | 49.956 |
| TOTAL INHOUSE | 9.928 | 7.619 |
| TOTAL INHOUSE RDT&E | 8.829 | 6.437 |
| ANNUAL OPERATING COST | 0.000 | 0.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 41 | 0 | 9 | 32 |
| CIVILIAN | 22 | 2 | 13 | 9 |
| TOTAL | 63 | 2 | 22 | 41 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1042 | 82.178 | 12.464 | 331.127 | 425.769 | 26.938 | 1.507 |

...MISSION

TO PROVIDE DEEP WATER DEV AND OPRTNL T&E FACLTYS FOR U/W ACOUSTIC MEASUREMENTS, TESTING, AND CALBRTN SONARS. PROVIDE ACCURATE U/W, SURFCE AND IN-AIR TRCKNG DATA ON SHIPS,SUBS,AIRCFT AND WEAPON SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

MK48 WEAPON SYSTEMS TRAINING CERTIFICATION PROGRAM
SHIP SILENCING PROGRAM
FLEET TRAINING/SUBROC,RANGEX,SHAREM
TORPEX/RANGEX
R&D TESTS/CAPTOR/MP SONAR/TOWED ARRAYS/LAMPS/BQQ 5/DICASS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

HIGHLY ADVNCD AND INSTRMNTD ASW WEAPONS,SONAR,AND FORACS TEST MEASURMNT RANGES IN SUPPORT OF NAVY ASW AND UNDERSEA R&D PROGRAMS,AND ASW FLEET ASSESSMENT AND OPERATIONAL READINESS.

INSTALLATION: UNDERWATER SYSTEMS CENTER NEWPORT,RI.

C.O. CAPT.J. W. AILES,IV TECH. DIR. MR. EARL MESSERE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 174.225 | 216.466 |
| TOTAL PROCUREMENT | 84.902 | 90.252 |
| TOTAL O&M | 115.644 | 131.679 |
| TOTAL OTHER | 11.083 | 24.605 |
| TOTAL ANNUAL LAB | 385.854 | 463.002 |
| TOTAL INHOUSE | 164.772 | 207.118 |
| TOTAL INHOUSE RDT&E | 94.004 | 121.022 |
| ANNUAL OPERATING COST | 59.004 | 73.405 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 79 | 0 | 30 | 49 |
| CIVILIAN | 2892 | 86 | 1640 | 1252 |
| TOTAL | 2971 | 86 | 1670 | 1301 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 381 | 1077.751 | 260.348 | 498.049 | 1836.148 | 54.651 | 65.500 |

...MISSION

TO BE THE PRINCIPAL NAVY RDT&E CTR FOR SUBMARINE WARFARE AND SUBMARINE WEAPON SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

ADVNCD TECHNGY IN U/W ACOUTCS,INFO PROCSNG, WEAPONRY.
DESGN,DEV & EVAL U/W COMBAT SUB SYSTMS INCDNG SUBACS & SURF SHIP SONAR.
RDT&E FOR OVERALL U/W COMBAT (TRIDENT,688,ETC.).
INTRODUCE TO FLT AND IN-SERV ENGINEERING OF MK48 & DEV OF MK48 ADCAP.
DESGN,DEV&EVAL OF LAUNCHERS,U/W TARGET SYS & MOBILE/FIXD U/W TEST RANGES

...FUNCTIONS/EQUIPMENT/CAPABILITIES

PRIMARY IN-HSE R&D CAPABILITY FOR NAVY U/W COMBAT SYSTEMS,SUBSYSTEMS AND TECHNLGYS FOR SONAR SYSTEMS (HULL-TOWD/SUB COMCTNS SYSTEMS INTEGRTN/SUB ANTNA SYSTEMS).U/W WPN RANGE TECHNLGY/REDINESS OF IN-SVC SHIPBOARD U/W SYSTEMS/ASW SUP.TORPEDO TEST RANGES(FIXD/PORTBLE)SHLOW AND DP WTR ASW WPN FIRE CTRL R&D FACILITY.ASW WPN LAUNCHING DEVICE R&D FACILITY,QLTY ENG, EVAL&RELIABILITY LAB,BERMUDA RSCH FACLTY,TORPEDO PROPULSN TEST FACLTY,ELECTMGNTC FACLTY,SYS CRTFCTN AND INTGRTN FACLTY,ACOUSTC MSMNT & XDUCER R&E FACLTY,TORPDO TEST RANGE.INSTMNT SHETER,ACOUSTC RANGE AUTEC.

INSTALLATION: WEAPONS CENTER CHINA LAKE,CA.

C.O. CAPT. K. A. DICKERSON TECH. DIR. DR. B. W. HAYS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 245.008 | 276.589 |
| TOTAL PROCUREMENT | 127.588 | 127.697 |
| TOTAL O&M | 33.838 | 83.518 |
| TOTAL OTHER | 52.890 | 76.158 |
| TOTAL ANNUAL LAB | 459.824 | 518.902 |
| TOTAL INHOUSE | 276.079 | 818.487 |
| TOTAL INHOUSE RDT&E | 173.281 | 204.044 |
| ANNUAL OPERATING COST | 65.758 | 85.876 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 570 | 0 | 88 | 582 |
| CIVILIAN | 4152 | 131 | 1602 | 2550 |
| TOTAL | 4722 | 131 | 1640 | 8082 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1127117 | 1746.309 | 268.692 | 4192.824 | 6202.825 | 288.143 | 114.368 |

...MISSION

THE PRINCIPAL NAVY RDT&E CENTER FOR AIR WARFARE SYSTEMS (EXCEPT ANTI-SUBMARINE WARFARE SYSTEMS) AND MISSILE WEAPON SYSTEMS, AND THE NATIONAL RANGE/FACILITY FOR PARACHUTE TEST AND EVALUATION.

...CURRENT IMPORTANT PROGRAMS

ANTI-AIR MSL AIM-9LM SIDEWINDER, AIM/RIM-7F/M SPARROW, ACIMD TECH DEMO ANTI-SURFACE WPNS A/RGM-84 HARPOON, CRUISE MISSILES, AND MSL COMPONENTS. ELECTRONIC W/F AGM-88 HARM, ALR-67, SIMULATION, EQUIPTS AND TACT EVALS TAC A/C SYS INTEGRATION A-7E, A-6E, AV-8B, FA-18, AIRCREW EQUIPMTS T AND E AIR/SURFACE-LAUNCHED WPNS, TACTICS, A/C WPN SYS, SUB/SYSTEMS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

CONDUCT IN-HOUSE RESEARCH AND ESTABLISH AND MAINTAIN PRIMARY IN-HOUSE DEVELOPMENT, TEST, EVALUATION, AND IN-SERVICE ENGINEERING SUPPORT FOR SPECIFIC NAVY, MARINE CORPS AND JOINT SERVICE PRODUCTS SUCH AS ANTI-AIR MISSILES, ANTI-SURFACE WEAPONS, DEFENSE PENETRATION SYSTEMS, INTEGRATED TACTICAL AIRCRAFT SYSTEMS. FACILITIES INCLUDE MICHELSON LAB, ELECTRONIC WARFARE THREAT ENVIRONMENT SIMULATION, SOLID STATE DEVICE LAB, ENCOUNTER SIMULATION LAB, PROPULSION RESEARCH LAB, MICROELECTRONICS FACILITY, EXPLOSIVES R&D FACILITIES, GROUND AND AIRCRAFT RANGES, EXTERIOR AND TERMINAL BALLISTICS RANGES, ARMITAGE AIR FIELD, PARACHUTE TEST TOWERS, SUPERSONIC TEST TRACKS, MICROWAVE ANECHOIC FACILITIES, RADIO-FREQUENCY AND INFRARED/ELECTRO-OPTICAL HARDWARE-IN-THE-LOOP SIMULATIONS, AND LASER/ELECTRO-OPTICS LABS.

TABLE 5A. AIR FORCE R&D LABORATORIES, PROGRAM AND PERSONNEL DATA, FY 1983

| INSTALLATION | FUNDING DATA (MILLIONS $) | | | | PERSONNEL DATA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL | TOTAL INHOUSE | TOTAL RDT&E | INHOUSE RDT&E | TOTAL MIL | TOTAL CIV | PHD MIL | PHD CIV | PROF MIL | PROF CIV |
| AERO PROPULSION LABORATORY | 119.123 | 7.910 | 117.755 | 6.542 | 45 | 339 | 3 | 27 | 39 | 218 |
| AEROSPACE MEDICAL RESEARCH LABORATORY | 32.160 | 18.556 | 30.557 | 16.953 | 137 | 152 | 27 | 27 | 65 | 103 |
| ARMAMENT LABORATORY | 74.239 | 30.624 | 68.571 | 29.338 | 165 | 348 | 4 | 15 | 153 | 246 |
| AVIONICS LABORATORY | 247.932 | 23.540 | 242.941 | 18.699 | 154 | 603 | 5 | 37 | 120 | 404 |
| ENGINEERING & SERVICES CNTR / RD | 18.886 | 4.158 | 16.230 | 1.610 | 82 | 19 | 6 | 2 | 45 | 12 |
| FLIGHT DYNAMICS LABORATORY | 165.572 | 11.762 | 160.693 | 6.883 | 183 | 648 | 2 | 34 | 135 | 432 |
| FRANK J SEILER RESEARCH LABORATORY | 2.075 | 2.075 | 1.167 | 1.167 | 23 | 9 | 9 | 1 | 17 | 5 |
| GEOPHYSICS LABORATORY | 82.141 | 33.087 | 78.407 | 29.637 | 122 | 488 | 3 | 98 | 39 | 304 |
| HUMAN RESOURCES LABORATORY | 53.956 | 14.192 | 48.156 | 11.330 | 134 | 240 | 11 | 47 | 75 | 145 |
| MATERIALS LABORATORY | 144.818 | 5.984 | 83.472 | 4.118 | 49 | 312 | 3 | 58 | 44 | 237 |
| ROCKET PROPULSION LABORATORY | 48.649 | 18.603 | 44.605 | 14.559 | 174 | 252 | 1 | 17 | 67 | 108 |
| ROME AIR DEVELOPMENT CENTER | 323.608 | 37.485 | 248.182 | 31.865 | 224 | 1108 | 5 | 62 | 114 | 629 |
| SCHOOL OF AEROSPACE MEDICINE | 30.223 | 21.018 | 23.301 | 14.096 | 368 | 265 | 48 | 39 | 81 | 102 |
| WEAPONS LABORATORY | 242.223 | 95.944 | 224.824 | 78.545 | 649 | 523 | 30 | 57 | 427 | 308 |
| TOTALS | 1585.605 | 324.938 | 1388.861 | 265.342 | 2509 | 5306 | 157 | 521 | 1421 | 3253 |

INSTALLATION: AERO PROPULSION LABORATORY WPAFB,OH.

DIR COL. JAMES D. JOHNSON CH. SCI DR. EDWARD T. CURRAN

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 117.755 | 126.837 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 1.868 | 1.441 |
| TOTAL ANNUAL LAB | 119.128 | 128.278 |
| TOTAL INHOUSE | 7.910 | 8.571 |
| TOTAL INHOUSE RDT&E | 6.542 | 7.180 |
| ANNUAL OPERATING COST | 7.842 | 7.620 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 45 | 3 | 39 | 6 |
| CIVILIAN | 339 | 27 | 218 | 121 |
| TOTAL | 384 | 30 | 257 | 127 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 44 | 266.165 | 47.779 | 123.889 | 437.833 | 79.080 | 34.760 |

...MISSION

PLAN AND EXECUTE RESEARCH, EXPLORATORY AND ADVANCED DEVELOPMENT PROGRAMS IN AIRBREATHING PROPULSION, AEROSPACE POWER, FUELS AND LUBRICATION, AND AIRCRAFT FIRE PROTECTION TECHNOLOGY. CONDUCT CONTRACT AND IN-HOUSE PROGRAMS, PROVIDE OPERATIONAL AND SYSTEM SUPPORT.

...CURRENT IMPORTANT PROGRAMS

ADVANCED TURBINE ENGINE GAS GENERATOR TECHNOLOGY
JOINT ADVANCED FIGHTER ENGINE (JFE) TECHNOLOGY
RAMJET TECHNOLOGY FOR TACTICAL AND STRATEGIC MISSILES
POWER TECHNOLOGY FOR MILITARY SPACECRAFT
OPTIMIZATION OF AVAILABILITY AND COST OF AVIATION TURBINE FUELS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

TURBINE ENGINE CONTROLS TEST FAC, BATTERY DEVELOPMENT AND TEST FAC, FIRE RESEARCH LAB, COKER LAB, FUEL ANALYSIS LAB, COMBUSTION FAC, ROTOR TEST FAC, 6 SEA-LEVEL ENGINE TEST STANDS-1 CAPABLE OF 60,000 LBS THRUST, 1 TURBINE ENGINE ALTITUDE CELL, 2 PROPELLER WHIRL RIGS-1 CAPABLE OF 10000 HP, DIRECT CONNECT RAMJET TEST FAC, RAMJET COMPONENTS LAB, LUBE TEST RIGS, SEAL TEST RIGS, BEARING TEST RIGS, FUEL HANDLING FAC, FIRE TEST SHELTER, SHAKER TABLE, HIGH TEMPERATURE TURBINE COMPONENT TEST FAC, AIRCRAFT ELECTRICAL POWER FAC WITH THREE 850 HP DRIVES, SUPERCONDUCTIVITY LAB, HIGH POWER LAB TO 5 MW, THERMAL ENERGY STORAGE LAB, HYDRAULICS LAB, PLASMA PHYSICS LAB, LASER HOLOGRAPHY LAB, COMPRESSOR TEST FACILITIES, SOLAR CELL LAB, HIGH SPEED DRIVE STAND, NACELLE SIMULATOR.

✓ INSTALLATION: AEROSPACE MEDICAL RESEARCH LABORATORY WPAFB,OH.

CDR. COL. GEORGE C. MOHR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 30.557 | 26.350 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.380 |
| TOTAL OTHER | 1.603 | 1.287 |
| TOTAL ANNUAL LAB | 32.160 | 28.017 |
| | | |
| TOTAL INHOUSE | 18.556 | 15.011 |
| TOTAL INHOUSE RDT&E | 16.953 | 14.418 |
| ANNUAL OPERATING COST | 0.844 | 0.898 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 137 | 27 | 65 | 72 |
| CIVILIAN | 152 | 27 | 103 | 49 |
| TOTAL | 289 | 54 | 168 | 121 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 30 | 1.257 | 105.887 | 105.887 | 213.031 | 11.062 | 27.047 |

...MISSION

ACCOMPLISH BEHAVIORIAL AND BIOMEDICAL RESEARCH AND DEVELOPMENT TO DEFINE HUMAN TOLERANCE AND DEGRADATION OF HUMAN PERFORMANCE UNDER THE CONDITION OF ENVIRONMENTAL STRESS ASSOCIATED WITH AEROSPACE OPERATIONS AND PROVIDE SUPPORT TO SYSTEM DEVELOPMENT IN THE ABOVE AREAS.

...CURRENT IMPORTANT PROGRAMS

OPERATOR COMMAND CONTROL AND COMMUNICATIONS TECHNOLOGY.CREW SYSTEMS AUTOMATION TECHNOLOGY. ADVANCED ESCAPE TECHNOLOGY.HUMAN COUNTERMEASURES TECHNOLOGY.ENVIRONMENTAL HEALTH PROTECTION TECHNOLOGY.MAN-IN-SPACE ALTERNATIVES TECHNOLOGY.CHEMICAL DEFENSE TECHNOLOGY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

HUMAN DECELERATION SYSTEM TO SIMULATE THE COMPLEX ACCELERATION ENVIRON ASSOCIATED WITH EJECTION AND CRASH LANDING.DYNAMIC ENVIRONMENT SIMULATOR A SIX DEGREE OF FREEDOM MAN-RATED CENTRIFUGE USED TO SIMULATE SUSTAINED ACCELERATIONS SUCH AS THOSE ENCOUNTERED IN AIR COMBAT MANEUVERING.THOMAS DOMES-EIGHT ALTITUDE EXPOSURE CHAMBERS TO SIMULATE EXOTIC ARTIFICIAL ATMOSPHERIC CONDITIONS.STRATEGIC AND TACTICAL COCKPIT SIMULATION FACILITIES USED TO PERFORM REAL-TIME MAN-IN-THE-LOOP EXPERIMENTS.ANECHOIC AND REVERBERATION CHAMBERS TO ENABLE EXPERIMENTAL INVESTIGATIONS OF POTENTIALLY HAZARDOUS NOISE TO DETERMINE EFFECTS ON BODY FUNCTION & PERFORMANCE.VIVARIUM-LABORATORY RESEARCH ANIMAL FACILITY.

INSTALLATION: ARMAMENT DIVISION EGLIN AFB,FL.

CDR. MAJ. GEN. W. T. TWINTING

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983 (ACTUAL) | 1984 (ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 539.266 | 555.859 |
| TOTAL PROCUREMENT | 495.218 | 892.559 |
| TOTAL O&M | 14.409 | 18.061 |
| TOTAL OTHER | 134.149 | 121.028 |
| TOTAL ANNUAL LAB | 1,183.037 | 1,582.007 |
| TOTAL INHOUSE | 298.460 | 834.818 |
| TOTAL INHOUSE RDT&E | 167.445 | 205.578 |
| ANNUAL OPERATING COST | 88.004 | 89.461 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 4880 | 2 | 514 | 4366 |
| CIVILIAN | 2081 | 24 | 942 | 1139 |
| TOTAL | 6961 | 26 | 1456 | 5505 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 463796 | 824.756 | 953.693 | 10123.933 | 11402.882 | 842.174 | 293.690 |

...MISSION

RESP. FOR AIR LAUNCH TACTICAL & AIR DEF MSLS; NONNUC MUN, GUIDED WEAP, THREAT SIMULATORS,AIRBASE DEF, & RELATED EQUIPMT. RESP. FOR BASIC TECHNOLOGY,DEVELOPMENT,TEST,INITIAL ACQ & DEPLOY. TEST MISSION IS LEAD CTR IN MUNITIONS, EC, INTRUSION, INTERDICTION, & CLIMACTIC SIMULATION.

...CURRENT IMPORTANT PROGRAMS

WIDE AREA ANTI-ARMOR MUNITIONS
PRECISION GUIDANCE MUNITIONS
ADVANCED MEDIUM RANGE AIR-TO-AIR MISSILE
RANGE SYSTEMS
RUNWAY CRATERING SUBMUNITIONS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

SCIENTIFIC/ENGINEERING PERSONNEL AND LABORATORY FACILITIES CAPABLE OF EXPLOR, ADV, AND ENGINEERING DEVELOPMENT OF NONNUCLEAR MUNITIONS AND EQUIPMENT. ARMAMENT SYSTEMS TEST ENVIRONMENT COVERING 725 SQ MILES WITH LARGE ADJACENT WATER AREA; HAS 28 TEST AREAS WITH INSTRUMENTED FACILITIES INCLUDING PRECISION TRACKING RADARS & PHOTO-OPTICS; IS USED FOR MUNITIONS TESTING & ELECTROMAGNETIC TEST ENVIRONMENT; AN INSTRUMENTED COMPLEX OF THREAT SYSTEMS FOR EVAL WPN SYS EFFECTIVENESS; PROVIDES A REALISTIC ENVIRONMENT FOR TESTING A WPN SYS AGAINST AN ACTIVE DEFENSE SYSTEM; A CLIMATIC LAB CAPABLE OF TESTING COMPLETE WEAPON SYSTEMS, A COMPUTER SCIENCE LAB, A PHYSICAL SCIENCE LAB, A PHOTO LAB, AN INSTRUMENTATION R/D FACILITY, AND A MISSILE SIMULATION AND TEST LABORATORY.

INSTALLATION: ARMAMENT LABORATORY EGLIN AFB FL

CDR. MAJ. GEN. W. T. TWINTING

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 68.571 | 71.812 |
| TOTAL PROCUREMENT | 1.250 | 1.115 |
| TOTAL O&M | 1.301 | 0.748 |
| TOTAL OTHER | 3.117 | 3.120 |
| TOTAL ANNUAL LAB | 74.239 | 76.295 |
| | | |
| TOTAL INHOUSE | 30.624 | 30.899 |
| TOTAL INHOUSE RDT&E | 29.338 | 29.954 |
| ANNUAL OPERATING COST | 0.000 | 0.000 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 165 | 4 | 153 | 12 |
| CIVILIAN | 348 | 15 | 246 | 102 |
| TOTAL | 513 | 19 | 399 | 114 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

...MISSION

AFATL IS SPECIFICALLY RESPONSIBLE FOR THE PLANNING, FORMULATION AND EXECUTION OF RESEARCH FOR EXPLORATORY AND ADVANCED DEVELOPMENT OF NON-NUCLEAR ARMAMENT AND RELATED EQUIPMENT, AS WELL AS TECHNICAL SUPPORT FOR ARMAMENT SYSTEMS.

...CURRENT IMPORTANT PROGRAMS

AFX - 400 EXPLOSIVES
IMPROVED 2000 POUND WARHEAD
INFRARED HIGH VALUE TARGET ACQUISITION
WEAPONS AIRFRAME TECHNOLOGY
HYPERVELOCITY MISSILE.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MAJOR EQUIPMENT INVENTORY CONSISTS OF A VARIETY OF ANALYZERS, SIMULATORS MIXER EQUIPMENT, AND MEASUREMENT MACHINES, SOME WITH RF, X-RAY AND LASER CHARACTERISTICS. AFATL FACILITIES INCLUDE 18 SEPARATE LABORATORIES FOR THE CONDUCT OF A WIDE RANGE OF SCIENTIFIC INVESTIGATIONS AND ANALYSES; A RAPID RESPONSE MODEL FABRICATION SHOP; AND A TECHNICAL LIBRARY WHICH HAS ON-LINE ACCESS TO SEVERAL DATA BANKS.

SPACE AND PROPERTY DATA AND ANNUAL OPERATING EXPENSES ARE INCORPERATED IN ARMAMENT DIVISION.

INSTALLATION: AVIONICS LABORATORY WPAFB,OH.

CDR. COL. BARTON KRAWETZ CH. SCI. DR. JESSE C. RYLES

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 242.941 | 344.871 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.150 | 0.000 |
| TOTAL OTHER | 4.841 | 5.035 |
| TOTAL ANNUAL LAB | 247.932 | 349.906 |
| TOTAL INHOUSE | 23.540 | 24.085 |
| TOTAL INHOUSE RDT&E | 18.699 | 19.050 |
| ANNUAL OPERATING COST | 8.191 | 9.200 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 154 | 5 | 120 | 34 |
| CIVILIAN | 603 | 37 | 404 | 199 |
| TOTAL | 757 | 42 | 524 | 233 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 220 | 229.369 | 9.483 | 405.264 | 644.116 | 45.602 | 99.989 |

...MISSION

MAINTAINS AN AVIONICS TECH BASE THROUGH RESEARCH, EXPLORATORY AND ADV DEV AND ASSIGNED BASIC RESEARCH PROGRAMS. DEV AND DEMO COST-EFFECTIVE AVIONICS TO REDUCE ACQUISITION AND OPERATING COSTS AND IMPROVE OPERATIONAL CAPABILITIES,SUPPORTS OPERATIONAL COMMANDS AND PRODUCT DIVISIONS.

...CURRENT IMPORTANT PROGRAMS

VERY HIGH SPEED INTEGRATED CIRCUITS TECHNOLOGY
SYNTHETIC APERATURE/BISTATIC RADAR
GALLIUM ARSENIDE POWER SOURCES FOR MICROWAVE APPLICATIONS
MONOPULSE RADAR COUNTERMEASURES
AUTOMATIC TARGET CLASSIFICATION.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

TECHNICAL AREAS OF RESPONSIBILITY INCLUDE - FIRE CONTROL, WEAPON DELIVERY, COMMUNICATIONS, ELECTRONIC WARFARE, NAVIGATION, SURVEILLANCE, RECONNAISSANCE, INFORMATION PROCESSING AND CONTROL, SUBSYSTEMS, INTEGRATION AND SYSTEMS ARCHITECTURE, SUPPORTING ELECTRONIC DEVICES. IN-HOUSE FACILITIES INCLUDE - SIMULATION AND ANALYSIS OF INTEGRATED DIGITAL SYSTEMS, DESIGN AND FABRICATION OF SPECIALIZED INTEGRATED/HYBRID CIRCUITS AND PRINTED WIRING BOARDS, PERFORMANCE EVALUATION OF E-O SYSTEMS AND CORRELATION WITH WEATHER OBSERVATION, SIMULATION OF REAL-WORLD SIGNAL/JAMMING ENVIRONMENT FOR EVALUATION OF ELECTRONIC WARFARE SYSTEMS, EVALUATION OF RECON SENSORS IN REALISTIC FLIGHT ENVIRONMENT. OTHER LABS ARE MAINTAINED FOR EVALUATION OF AIRBORNE AND SPACE SENSORS AND COMPONENTS FROM OPTICAL TO RADIO FREQUENCIES.

√ INSTALLATION: ENGINEERING & SERVICES CNTR / RD TYNDALL AFB,FL.

CDR. COL. ROBERT BOYER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 16.230 | 12.026 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.399 | 0.812 |
| TOTAL OTHER | 2.257 | 2.482 |
| TOTAL ANNUAL LAB | 18.886 | 14.820 |
| TOTAL INHOUSE | 4.158 | 8.236 |
| TOTAL INHOUSE RDT&E | 1.610 | 0.444 |
| ANNUAL OPERATING COST | 0.169 | 0.184 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 82 | 6 | 45 | 37 |
| CIVILIAN | 19 | 2 | 12 | 7 |
| TOTAL | 101 | 8 | 57 | 44 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 3 | 12.000 | 14.000 | 0.000 | 26.000 | 1.960 | 2.656 |

...MISSION

AIR FORCE LEAD AGENCY FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION IN THE AREAS OF CIVIL ENGINEERING AND ENVIRONMENTAL QUALITY. AF FOCAL POINT FOR ENVIRONMENTAL QUALITY AND LEAD LABORATORY FOR FACILITIES ENERGY.

...CURRENT IMPORTANT PROGRAMS

RAPID RUNWAY REPAIR AND NEW AIRCRAFT OPERATIONAL SURFACES
ENVIRONMENTAL QUALITY AND ASSESSMENT RESEARCH AND DEVELOPMENT
SURVIVABILITY/VULNERABILITY OF FACILITIES
FACILITIES ENERGY AND ALTERNATE ENERGY SOURCES
FIRE PROTECTION

...FUNCTIONS/EQUIPMENT/CAPABILITIES

ESL HAS ACCESS TO LABORATORIES AND TEST FACILITIES TO PERFORM QUALITATIVE AND QUANTITATIVE MEASUREMENTS ON ENGINEERING MATERIALS, PAVEMENTS, SOIL MECHANICS, AIR QUALITY, WASTE TREATMENT PROCESSES, FIRE EXTINGUISHING AGENTS, AND HARDENED AIRCRAFT SHELTERS. EQUIPMENT INCLUDES FLAME AND ABSORPTION SPECTROPHOTOMETERS, WATER/WASTE STANDARD METHODS TEST EQUIPMENT, ELECTRICAL AEROSOL ANALYZING EQUIPMENT, LASER PARTICLE SIZE MEASUREMENT EQUIPMENT, AND MICROPROCESSOR DEVELOPMENT SYSTEMS. REMOTE TERMINAL ACCESS IS AVAILABLE TO CYBER 171 AND 176 SCIENTIFIC COMPUTERS WITH OFF LINE PLOTTING CAPABILITY. A RUNWAY REPAIR /ALTERNATE LAUNCH SURFACE TEST SITE HAS A 200 X 600 FOOT TYPICAL RUNWAY SECTION

INSTALLATION: FLIGHT DYNAMICS LABORATORY WPAFB,OH.

ACT. DIR. MR. J. J. MATTICE CH. SCI DR. G. KEITH RICHEY

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 160.693 | 169.878 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 4.879 | 5.080 |
| TOTAL ANNUAL LAB | 165.572 | 174.458 |
| TOTAL INHOUSE | 11.762 | 12.880 |
| TOTAL INHOUSE RDT&E | 6.883 | 7.750 |
| ANNUAL OPERATING COST | 10.915 | 11.200 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 183 | 2 | 135 | 48 |
| CIVILIAN | 648 | 84 | 432 | 216 |
| TOTAL | 831 | 86 | 567 | 264 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 76 | 546.654 | 5.100 | 168.182 | 719.936 | 50.676 | 42.043 |

...MISSION

PLAN AND EXECUTE RESEARCH, EXPLORATORY AND ADV DEV PROGRAMS FOR AEROSPACE FLT VEHICLE STRUCTURES, AERODYNAMICS, FLT CONTROL, DYNAMICS AND EQUIPMENT. LEAD AFSC LAB FOR EXPERIMENTAL FLT VEHICLES. FOCAL POINT FOR NON-NUCLEAR SURVIVABILITY PROGRAMS.

...CURRENT IMPORTANT PROGRAMS

ADVANCED FIGHTER TECHNOLOGY INTEGRATOR
ADVANCED COMPOSITE AND METALLIC STRUCTURES
INTEGRATED FLIGHT MANAGEMENT
BOOST-GLIDE VEHICLE TECHNOLOGY
SHORT TAKE-OFF/LANDING AND ROUGH FIELD TECHNOLOGY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

A BATTLE DAMAGED REPAIRED COMPOSITE OUTER WING PANEL SUCCESSFULLY COMPLETED 2000 HRS OF FATIGUE CYCLING IN THE STRUCTURES TEST FACILITY, FULL QUALIFICATION OF THE F-16 REFURBISHED GENERATION 4 AND 5 CARBON BRAKES WAS ACHIEVED IN THE LANDING GEAR DEVELOPMENT FACILITY. INVESTIGATION OF AN ADVANCED BRAKE CONTROL SYSTEM WAS PERFORMED IN THE ENGINEERING FLIGHT SIMULATION FACILITY. HALON 1301 FIRE EXTINGUISHING-DRY BAY EFFECTIVENESS WAS DEMONSTRATED IN THE AIRCRAFT SURVIVABILITY RESEARCH BALLISTIC RANGE. TESTS IN THE MACH 8 FACILITY DEFINED ROUGHNESS EFFECTS ON TURBULENT BOUNDARY LAYER CHARACTERISTICS FOR SUPERSONIC FLOWS AT HIGH REYNOLDS NUMBERS. A SERIES OF LIGHTNING SIMULATION TESTS ON AN OPERATIONAL F-16 WITH EXTERNAL FUEL TANKS INSTALLED WERE PERFORMED IN THE ATMOSPHERIC ELECTRICITY HAZARDS SIMULATION FACILITY.

INSTALLATION: FRANK J SEILER RESEARCH LABORATORY USAF ACADEMY,CO.

CDR. LT. COL. T. T. SAITO CH. SCI. LT. COL. K. E. SIEGENTHALER

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 1.167 | 1.412 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 0.908 | 0.934 |
| TOTAL ANNUAL LAB | 2.075 | 2.346 |
| | | |
| TOTAL INHOUSE | 2.075 | 2.346 |
| TOTAL INHOUSE RDT&E | 1.167 | 1.412 |
| ANNUAL OPERATING COST | 0.114 | 0.142 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 23 | 9 | 17 | 6 |
| CIVILIAN | 9 | 1 | 5 | 4 |
| TOTAL | 82 | 10 | 22 | 10 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 0 | 190.000 | 8.000 | 0.000 | 198.000 | 1.820 | 2.628 |

...MISSION

CONDUCT RESEARCH IN LASERS, AEROMECHANICS, AND CHEMISTRY. ENCOURAGE AND SUPPORT ACADEMY FACULTY & CADET RESEARCH BY DIRECT PARTICIPATION. SPONSOR FACULTY RESEARCH PROGRAMS. FOCAL POINT FOR USAF ACADEMY RESEARCH PROPOSED TO DL RESEARCH & TECHNOLOGY LABS (AFSC).

...CURRENT IMPORTANT PROGRAMS

BATTERY RESEARCH & ELECTROCHEMISTRY OF MOLTEN SALTS,ENERGETIC MATERIALS RESEARCH, THEORETICAL CALCULATIONS, I LASER RESEARCH, LASER DAMAGE STUDIES, OPTICAL ROTATION SENSORS, OPTICS RESEARCH, PERIODIC CONTROL, NUCLEAR GYROS, IMAGE PROCESSING.

UNSTEADY AERODYNAMICS, INTEGRATED AIRBREATHING PROPULSION.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MOLTEN SALT MELT STRUCTURE,CONDUCTIVITY&ELECTRODE REACTIONS.EXPLOSIVE& PROPELLANT SYNTH.DECOMPOSITION MECHANISMS&DETONATION PHENOMENA.GENERATION,MSMT,SPECTROSCOPY&MO CALC.OF EXCITED STATE SPECIES.FTIR,UV,FTNMR, EPR,X-RAY&MASS SPEC.GAS&LIQUID CHROMATOGRAPH,ELECTRON MICROSCOPE,SPECIAL SPECTROMETERS & CONDUCTIVITY EQUIP. ASSOC.FACILITIES FOR WET CHEMISTRY. ADVANCED ANALYSIS&EVALUATION TECHNIQUES FOR INERTIAL GUIDANCE SENSORS USING 2-AXIS TEST TABLE(GYRO),AUTOMATIC AZIMUTH ALIGNMENT EQUIPMENT&ELECTRONIC CONTROL EQUIP FOR 50 SERIES INERTIAL DEVICES LOCATED IN A CLASS 1000 CLEAN LAB ON 80 TON AIR SUPPORTED STABLE PLATFORM. VAX 11/780 MINICOMPUTER&SOFTWARE TO AUTOMATE GYRO RESEARCH. EXCIMER,DYE LASERS. AERO RESEARCH IN USAFA SUBSONIC&TRISONIC WIND TUNNELS. HOLOGRAPHIC&OTHER OPTICAL FLOW VISUALIZATION INSTRUMENTATION.

INSTALLATION: GEOPHYSICS LABORATORY HANSCOM AFB,MA.

√CDR. COL. GERALD P. D'ARCY CH. SCI. DR. ALVA T. STAIR JR

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 78.407 | 82.444 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 3.734 | 5.748 |
| TOTAL ANNUAL LAB | 82.141 | 88.192 |
| | | |
| TOTAL INHOUSE | 38.087 | 34.272 |
| TOTAL INHOUSE RDT&E | 29.637 | 31.146 |
| ANNUAL OPERATING COST | 5.881 | 6.175 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 122 | 8 | 39 | 83 |
| CIVILIAN | 488 | 93 | 304 | 184 |
| TOTAL | 610 | 101 | 343 | 267 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 336 | 393.389 | 14.821 | 25.883 | 434.093 | 9.871 | 35.279 |

...MISSION

CONDUCTS AND SUPPORTS AF RELEVANT RESEARCH AND EXPLORATORY DEVELOPMENT IN ENVIRONMENTAL AND PHYSICAL SCIENCES WITH MAJOR EMPHASIS ON GEOPHYSICS. ALSO CONDUCTS AND SUPPORTS SPECIFICALLY ASSIGNED ADVANCED DEVELOPMENT EFFORTS.

...CURRENT IMPORTANT PROGRAMS

SPACE ENVIRONMENT
WEATHER FORECAST AND OBSERVING AUTOMATION
IONOSPHERIC SPECIFICATION FOR C3I SYSTEMS
OPTICAL, INFRARED AND UV BACKGROUNDS FOR SURVEILLANCE SYSTEMS
GEODETIC AND EARTH MOTION EFFECTS ON MISSILE CEP.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

CONDUCTS RESEARCH AND TECHNICAL DEVELOPMENT IN TERRESTRIAL SCIENCES, ATMOSPHERIC SCIENCES, AND IONOSPHERIC, OPTICAL, SPACE AND SOLAR PHYSICS RELATING TO AIR FORCE NEEDS. EQUIPMENT AND FACILITIES INCLUDE IN-HOUSE LABORATORIES, SPACE SIMULATION CHAMBERS, ROCKET AND BALLOON LAUNCH FACILITIES, AND TWO KC-135 AIRCRAFT FOR OPTICAL, UPPER ATMOSPHERIC AND IONOSPHERIC STUDIES.

INSTALLATION: HUMAN RESOURCES LABORATORY BROOKS AFB,TX.

CDR. COL. ALFRED A. BOYD JR CH. SCI. DR. EARL A. ALLUISIST

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 48.156 | 48.748 |
| TOTAL PROCUREMENT | 0.215 | 0.000 |
| TOTAL O&M | 2.549 | 4.555 |
| TOTAL OTHER | 3.036 | 3.602 |
| TOTAL ANNUAL LAB | 53.956 | 56.905 |
| | | |
| TOTAL INHOUSE | 14.192 | 15.402 |
| TOTAL INHOUSE RDT&E | 11.830 | 11.800 |
| ANNUAL OPERATING COST | 2.678 | 2.378 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 134 | 11 | 75 | 59 |
| CIVILIAN | 240 | 47 | 145 | 95 |
| TOTAL | 374 | 58 | 220 | 154 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 5 | 81.180 | 58.219 | 56.132 | 195.531 | 6.521 | 75.215 |

...MISSION

PLAN AND EXECUTE RESEARCH, EXPLORATORY DEVELOPMENT, AND ADVANCED DEVELOPMENT PROGRAMS IN TRAINING AND PERSONNEL SYSTEMS TECHNOLOGY.

...CURRENT IMPORTANT PROGRAMS

MANPOWER AND PERSONNEL PROGRAMS IN SELECTION, CLASSIFICATION AND RETENTION; EDUCATION AND TRAINING PROGRAMS IN TECHNICAL TRAINING, FLYING TRAINING AND CREW AND TEAM TRAINING; SIMULATION AND TRAINING DEVICES PROGRAMS DEVELOPING FLIGHT AND MAINTENANCE TRAINING SIMULATORS; LOGISTICS PROGRAMS IN COMBAT MAINTENANCE.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

THE ADVANCED SIMULATOR FOR PILOT TRAINING CONSISTING OF TWO COCKPITS ON A SIX DEGREES OF FREEDOM MOTION BASE WITH WIDE-ANGLE INFINITY VISUAL DISPLAYS AND A COMPUTER IMAGE GENERATION SYSTEM. THE ADVANCED INSTRUCTIONAL SYSTEM COMPUTER BASED TRAINING SYSTEM OFFERING INDIVIDUALIZED, ADAPTIVE TRAINING TO MAXIMIZE INDIVIDUAL LEARNING PERFORMANCE. THE UNIVAC 1100/81 COMPUTER SYSTEM USED FOR R&D IN ALL FACETS OF PERSONNEL SELECTION, TRAINING, MANAGEMENT AND RETENTION, THE BASIC RESEARCH TRAINING AND TESTING LABORATORY IS USED FOR EXPLORING NEW TECHNIQUES IN THE MEASUREMENT OF INDIVIDUAL DIFFERENCES IN LEARNING AND PERFORMANCE CAPABILITIES

INSTALLATION: MATERIALS LABORATORY WPAFB,OH.

✓ DIR. MR. GEORGE P. PETERSON CH. SCI DR. HARRIS M. BURTE

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 83.472 | 85.158 |
| TOTAL PROCUREMENT | 52.395 | 57.500 |
| TOTAL O&M | 7.085 | 0.000 |
| TOTAL OTHER | 1.866 | 1.941 |
| TOTAL ANNUAL LAB | 144.818 | 144.599 |
| | | |
| TOTAL INHOUSE | 5.984 | 6.711 |
| TOTAL INHOUSE RDT&E | 4.118 | 4.770 |
| ANNUAL OPERATING COST | 5.688 | 5.750 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 49 | 3 | 44 | 5 |
| CIVILIAN | 312 | 58 | 237 | 75 |
| TOTAL | 361 | 61 | 281 | 80 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 15 | 188.750 | 117.941 | 54.123 | 360.814 | 23.840 | 66.483 |

...MISSION

PLAN/EXECUTE EXPLORATORY AND ADVANCED DEVELOPMENT, AND ASSIGN BASIC RESEARCH PROGRAMS FOR MATERIALS, PROVIDE TECHNICAL AND MANAGEMENT ASSISTANCE FOR STUDIES, ANALYSIS,DEV PLANNING, TEST, EVAL, MOD AND OPERATION OF AEROSPACE SYS. MANAGE AF DIRECTED MANUFACTURING PROGRAMS.

...CURRENT IMPORTANT PROGRAMS

ADVANCED DEVELOPMENT OF LASER-HARDENED MATERIALS
STRUCTURAL MATERIALS FOR AEROSPACE SYSTEMS
THERMAL PROTECTION MATERIALS
PROPULSION MATERIALS
ELECTRONIC MATERIALS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MATERIALS RESEARCH AND DEVELOPMENT FACILITIES AND CAPABILITIES FOR AEROSPACE STRUCTURES, THERMAL PROTECTION SYSTEMS FOR BALLISTIC REENTRY VEHICLES AND ENGINES, FLUIDS, LUBRICANTS, FLUID CONTAINMENT, PROPULSION COATINGS, FIBERS, ELECTROMAGNETIC WINDOWS, SENSORS, LASER WINDOWS AND OPTICAL DEVICES, ELECTRICAL COMPONENTS, NON-DESTRUCTIVE TESTING, POLYMERS, ADHESIVES, NON-METALLIC MATRIX COMPONENTS, ELASTOMERS, METALS, ALLOYS, METAL MATRIX COMPOSITES, METAL PROCESSING, CERAMICS, STATIC AND DYNAMIC BEHAVIOR, GRAPHITE, ELECTRONIC/PHYSICAL/CHEMICAL ANALYSIS, OTHER MAJOR MATERIAL FUNCTIONS WHICH INCLUDE MANUFACTURING TECHNOLOGY, SYSTEMS APPLICATIONS, SYSTEMS SUPPORT AND THERMAL PROTECTION MATERIALS.

INSTALLATION: ROCKET PROPULSION LABORATORY EDWARDS AFB,CA.

CDR. LT. COL. JOHN KOGER DIR. MR. DON HART

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 44.605 | 43.700 |
| TOTAL PROCUREMENT | 0.012 | 0.015 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 4.032 | 4.153 |
| TOTAL ANNUAL LAB | 48.649 | 47.868 |
| TOTAL INHOUSE | 18.603 | 19.568 |
| TOTAL INHOUSE RDT&E | 14.559 | 15.400 |
| ANNUAL OPERATING COST | 0.925 | 0.960 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 174 | 1 | 67 | 107 |
| CIVILIAN | 252 | 17 | 108 | 144 |
| TOTAL | 426 | 18 | 175 | 251 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 68345 | 419.046 | 86.848 | 4.780 | 510.674 | 126.000 | 27.180 |

...MISSION

CONDUCT THE AIR FORCE'S ROCKET PROPULSION AND INTERDISCIPLINARY SPACE TECHNOLOGY RESEARCH, EXPLORATORY, AND ADV DEVEL PROGRAMS FOR FUTURE ICBMS, AIR LAUNCHED MISSILES, SPACE VEHICLES, AND SATELLITES. PROVIDES ROCKET PROPULSION TECHNOLOGICAL SUPPORT TO DOD AND NON-DOD AGENCIES.

...CURRENT IMPORTANT PROGRAMS

PROVIDE PROPULSION OPTIONS FOR SMALL MOBILE BALLISTIC MISSILES. PROVIDE HIGH PERFORMANCE & PROPULSION FLEXIBILITY OPTIONS FOR TACTICAL MISSILES PROVIDE LOW AIR LAUNCHED MISSILE PROPULSION SIGNATURE. PROVIDE PROPULSION OPTIONS FOR SPACE SYSTEMS DEPLOYMENT. DEMONSTRATE HIGHER PERFORMANCE NON-CONVENTIONAL PROPULSION CONCEPTS.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

LABORATORIES FOR SYNTHESIS, ANALYSIS AND FORMULATION OF NEW PROPELLANTS. FACILITIES FOR MIXING, CASTING, CURING AND TESTING SOLID ROCKET MOTORS. SOLID MOTOR EXPERIMENTAL COMPLEX FOR INVESTIGATION OF COMBUSTION, AGING, STRUCTURAL INTEGRITY, BALLISTIC PERFORMANCE AND HIGH TEMP COMPONENTS. LAB FOR EXPERIMENTATION OF SMALL ATTITUDE CONTROL AND SATELLITE PROPULSION SYSTEMS AND COMPONENTS UNDER SIMULATED SPACE ENVIRONMENTS. ALTITUDE EXPERIMENTATION OF LIQUID AND SOLID ROCKETS UP TO 50,000 POUNDS THRUST. AMBIENT EXPERIMENTATION OF LIQUID OR SOLID ROCKETS UP TO 10,000,000 POUNDS THRUST. IN-HOUSE ANALYTICAL CAPABILITY FOR DESIGN, ANALYSIS, AND DATA REDUCTION. SHOPS FOR FABRICATING EXPERIMENTAL HARDWARE AND SYSTEMS.

INSTALLATION: ROME AIR DEVELOPMENT CENTER GRIFFISS AFB,N.Y.

CDR. COL. CHARLES F. STEBBINS CH. SCI. DR. FRED I. DIAMOND

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 248.182 | 251.432 |
| TOTAL PROCUREMENT | 17.245 | 23.865 |
| TOTAL O&M | 52.388 | 56.547 |
| TOTAL OTHER | 5.793 | 7.233 |
| TOTAL ANNUAL LAB | 323.608 | 338.577 |
| TOTAL INHOUSE | 37.485 | 39.855 |
| TOTAL INHOUSE RDT&E | 31.865 | 33.454 |
| ANNUAL OPERATING COST | 14.408 | 15.108 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 224 | 5 | 114 | 110 |
| CIVILIAN | 1108 | 62 | 629 | 479 |
| TOTAL | 1332 | 67 | 743 | 589 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 1517 | 764.945 | 52.839 | 182.271 | 1000.055 | 29.595 | 56.243 |

...MISSION

CONDUCTS RESEARCH,EXPLORATORY AND ADVANCED DEVELOPMENT,TEST AND SELECTED ENGINEERING DEVELOPMENT AND ACQUISITION SUPPORT PROGRAMS IN SUPPORT OF COMMAND,CONTROL AND COMMUNICATIONS AND INTELLIGENCE ACTIVITIES.

...CURRENT IMPORTANT PROGRAMS

ADVANCED TACTICAL RADAR
SPACE BASED RADAR
COMMAND,CONTROL AND COMMUNICATIONS DECISION AIDS
SATELLITE COMMUNICATIONS
FIBER OPTICS

...FUNCTIONS/EQUIPMENT/CAPABILITIES

MAJOR AREAS OF TECHNOLOGY ARE ANTENNAS,SIGNAL PROCESSING,SOLID STATE COMPONENTS,THERMIONICS,OPTO-ELECTRONICS,RADIATION HARDENING,SYSTEM AND COMPONENT RELIABILITY,SOFTWARE,ARTIFICIAL INTELLIGENCE-WITH EMPHASIS ON DECISION AIDS,AND RECONNAISSANCE AND INTELLIGENCE DATA HANDLING.MAJOR IN-HOUSE FACILITIES ARE:RECONNAISSANCE EXPLOITATION FACILITY,HIGH POWER FACILITY,DIGITAL COMMUNICATIONS EXPERIMENTAL FACILITY,R AND D COMPUTER FACILITY FEATURING TWO HONEYWELL 6180 COMPUTERS WITH MILTICS,RELIABILITY ANALYSIS CENTER,RADIATION EFFECTS FACILITY,EXPERIMENTAL PHOTOGAMMETRIC FACILITY,ECCM AND SIGNAL PROCESSING LABORATORY,SOLID STATE DEVICE FAILURE ANALYSIS FACILITY,EXPERIMENTAL DEVICE FABRICATION FACILITY,ELECTROMAGNETIC VULNERABILITY FACILITY FOR WEAPONS TESTING,SURVEILLANCE LABORATORY,AND MATERIALS SYNTHESIS AND DEVELOPMENT FACILITY.

INSTALLATION: SCHOOL OF AEROSPACE MEDICINE BROOKS AFB,TX.

CDR. COL. DR. EDWARD MOSER VICE CDR. COL. JEFFERY G. DAVIS

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 23.301 | 22.310 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.116 | 0.000 |
| TOTAL OTHER | 6.806 | 7.078 |
| TOTAL ANNUAL LAB | 30.223 | 29.388 |
| TOTAL INHOUSE | 21.018 | 20.618 |
| TOTAL INHOUSE RDT&E | 14.096 | 13.535 |
| ANNUAL OPERATING COST | 3.500 | 3.640 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 368 | 48 | 81 | 287 |
| CIVILIAN | 265 | 39 | 102 | 163 |
| TOTAL | 633 | 87 | 183 | 450 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 46 | 436.163 | 53.341 | 198.237 | 687.741 | 18.120 | 24.556 |

...MISSION

CONDUCT EXPLORATORY RESEARCH AND DEVELOPMENT PROGRAMS IN AEROSPACE BIOTECHNOLOGY, INCLUDES LIFE SUPPORT, AEROSPACE MEDICINE, BIOMEDICAL PROGRAMS AND RADIOBIOLOGY. PROVIDE MEDICAL EVALUATION AND CONSULTATION FOR AIRCREWS TO ASSURE RETENTION OF FLYING STATUS.

...CURRENT IMPORTANT PROGRAMS

CHEMICAL WARFARE DEFENSE.
RADIATION AND DIRECTED ENERGY BIOEFFECTS.
CREW READINESS AND PROTECTIVE EQUIPMENT.
AEROMEDICAL ASPECTS OF AEROSPACE OPERATIONS.
SPACE BIOTECHNOLOGY.

...FUNCTIONS/EQUIPMENT/CAPABILITIES

RESEARCH IN AEROSPACE MEDICAL PROBLEMS, LIFE SUPPORT, ENVIRONMENTAL STRESS, RADIOBIOLOGY, LASER, BIOMETRICS, BIOMED ENGINEERING, RDTE ON MEDICAL EQUIPMENT AND SYSTEMS, WHOLE BODY COUNTER, HUMAN CENTRIFUGE, TESTING CELLS, RESEARCH CHAMBERS, TELETHERAPY COBALT 60 RADIATION SOURCE, RADIOFREQUENCY RADIATION FACILITY, ELECTRON MICROSCOPE SYSTEM, REMOTE INTERACTIVE GRAPHIC TERMINAL SYSTEM, THERMAL CHAMBER, CARDIAC CATH LAB, AEROSP MED SCIENCE LAB, LASER HAZARD FACILITIES, AEROMEDICAL LIBRARY,AEROSP MED EVALUATION AND CONSULTATIVE SERVICES, OPTICAL RESEARCH AUDIOLOGY, VESTIBULAR STUDIES, PSYCHOBIOLOGY, RADIOISOTOPE, AEROMED STANDARDS, MODELING, BIOMED RESEARCH, MEDICAL REPOSITORIES, RADIATION SCIENCES RESEARCH, BIODYNAMICS RESEARCH, DEVELOP ENGINEERING.

INSTALLATION: WEAPONS LABORATORY KIRTLAND AFB, N.M.

CDR COL T. M. JOHNSON VCDR COL J. M. WALTON

PROGRAM DATA BY FISCAL YEAR (MILLION $)

| PROGRAM | 1983<br>(ACTUAL) | 1984<br>(ACT + EST) |
|---|---|---|
| TOTAL RDT&E | 224.824 | 260.002 |
| TOTAL PROCUREMENT | 0.000 | 0.000 |
| TOTAL O&M | 0.000 | 0.000 |
| TOTAL OTHER | 17.399 | 18.269 |
| TOTAL ANNUAL LAB | 242.223 | 278.271 |
| TOTAL INHOUSE | 95.944 | 109.095 |
| TOTAL INHOUSE RDT&E | 78.545 | 90.826 |
| ANNUAL OPERATING COST | 15.414 | 15.106 |

PERSONNEL DATA (END OF FY 1983)

| PERSONNEL | AUTHORIZED STRENGTH | TOTAL PHDS | TOTAL PROF | NON-PROF |
|---|---|---|---|---|
| MILITARY | 649 | 80 | 427 | 222 |
| CIVILIAN | 523 | 57 | 808 | 215 |
| TOTAL | 1172 | 87 | 735 | 437 |

SPACE AND PROPERTY

| ACRES | SPACE (THOUSANDS OF SQUARE FEET) | | | | COST (MILLION $) | |
|---|---|---|---|---|---|---|
| | LAB | ADMIN | OTHER | TOTAL | REAL PROP | EQUIP |
| 702 | 655.000 | 130.000 | 182.000 | 967.000 | 75.595 | 93.530 |

...MISSION

RESPONSIBLE FOR EXPLORATORY, ADVANCED, AND ENGINEERING DEVELOPMENT IN NUCLEAR WEAPONS EFFECTS, COMPONENTS, NUCLEAR SURVIVABILITY/VULNERABILITY, HIGH ENERGY LASER SYSTEMS, ADVANCED WEAPON CONCEPTS AND TECHNOLOGY, AND NUCLEAR SAFETY.

...CURRENT IMPORTANT PROGRAMS

ADVANCED RADIATION TECHNOLOGY
ADVANCED WEAPON TECHNOLOGY
NUCLEAR SURVIVABILITY/VULNERABILITY ANALYSIS AND TESTING
NUCLEAR SAFETY ANALYSIS AND DESIGN CRITERIA
NUCLEAR WEAPONS EFFECTS ANALYSIS AND TESTING

...FUNCTIONS/EQUIPMENT/CAPABILITIES

NUCLEAR WEAPONS EFFECTS SIMULATION, SAFETY, COMPONENT ASSESSMENT AND ANALYSIS OF WEAPONS SYSTEMS NUCLEAR HARDNESS ARE CONDUCTED IN ENGINEERING TEST LABORATORIES AND PHYSICS LABORATORIES. SIMULATION TESTS ON MISSILES, AIRCRAFT, AND COMPONENTS USE ELECTROMAGNETIC PULSE SIMULATORS, GAS GUNS, AND X-RAY DEVICES. CIVIL ENGINEERING PROGRAMS USE SHOCK TUBES AND HIGH EXPLOSIVES FOR SIMULATION OF NUCLEAR BLAST AND SHOCK. LASER SYSTEMS DEVELOPMENT USES LASER/OPTICS LABORATORIES AND TEST RANGES WITH LARGE, HIGH POWER DEVICES. A TECHNICAL LIBRARY, METALLURGY AND METROLOGY LABORATORIES, 1 CRAY, 2 CDC-730 AND 1 IBM-4341 COMPUTERS WITH REMOTE ACCESS TERMINALS AND MULTI-CHANNEL SENSING/ RECORDING AND DATA REDUCTION SUPPORT ALL REQUIRING RDT/E PROGRAMS.

# CHAPTER VII

## DEPARTMENT OF DEFENSE SUPPORT OF RDT&E IN INDUSTRY [1]

### A. INTRODUCTION

Most of DOD's funds for RDT&E are spent by industrial firms under contract to the Services or to one of the Defense agencies that support such work. It is estimated that FY87 DOD funds for RDT&E performed in industry will total nearly $27 billion.[2] Taken as a whole, DOD's industrial RDT&E "program" is the largest R&D activity in the free world.[3] It is larger, for example, than the total amount spent on research and development for all purposes and by all sources in such countries as West Germany, France, and the United Kingdom, and is nearly as large as the entire R&D efforts of Japan.[4] A substantial proportion of DOD's RDT&E activity is classified, with some classified not only in technical detail but even as to its very existence.

This chapter provides only the most cursory survey of this enormous R&D activity, with a focus on support of basic research and "technology base" research and development. It describes the historical evolution of industrial performance of DOD RDT&E programs, along with the markets for such performance as compared with the markets for DOD contract procurements, to which RDT&E is tightly connected. It also describes in some detail four specific RDT&E programs that DOD supports in industry that are intended to promote the development of fundamental scientific and technical understanding underlying important areas of defense-related technology, and to promote the entry into defense-related R&D of small firms and their associated new technologies. It ends with a discussion of a few of the many important policy issues that arise in connection with DOD support of RDT&E in industry.

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[1] Prepared by Joan D. Winston and Christopher T. Hill. Ms. Winston is Analyst, Office of Technology Assessment, U.S. Congress. Dr. Hill is Senior Specialist in Science and Technology Policy, Congressional Research Service. This work was carried out while Ms. Winston was a Senior Research Assistant, Office of Senior Specialists, Congressional Research Service.

[2] National Science Foundation, Federal Funds for Research and Develoment: fiscal years 1985, 1986, and 1987. Volume XXXV (Detailed Statistical Tables), p. 17, undated.

[3] DOD has officially estimated that Soviet military R&D expenditures were twice those of the U.S. from 1973 to 1982. See, Office of the Secretary of Defense, Soviet Military Power, 1984, April 1984, p. 99. However, such direct comparisons are very problematic. See Stockholm International Peace Research Institute, World Armaments and Disarmament:SIPRI Yearbook 1983, Taylor and Francis: London, 1983, pp. 228-243, for a discussion of various methods of estimating Soviet R&D expenditures and of limitations on such estimates.

[4] See, for example, National Science Foundation, International Science and Technology Data Update 1986, Report NSF 86-307, p. 1.

## B. The Place of DOD in Federal Support of R&D in Industry

The DOD sponsored research and development programs carried out in the industrial [5] sector differ substantially from the university-based, research-focused programs discussed elsewhere in this report. DOD funding levels differ markedly between industry and the universities: although DOD funding for basic research in universities is nearly five times that in industry, twenty times as much DOD money for all categories of research and development goes to industrial performers as to universities. The range and scope of activities carried out by industry and by the universities differ dramatically. In contrast to DOD R&D done in universities, most DOD R&D in industry is interdisciplinary and at the development end of the continuum. The "university model" of basic scientific research organized and funded by field of science or engineering does not fit the program-oriented development carried out by teams of scientific and technical personnel employed by DOD industrial contractors and consortia.

Historically, the Department of Defense (DOD) has been an important sponsor of R&D performed by industry, particularly since the onset of WW-II.[6] After WW-I—during which commercial military procurement had surged and industry leaders had assumed prominent roles in wartime production planning—much military production shifted back to the arsenals. Similarly, the locus of U.S. research remained in the universities in the inter-war period.

During WW-II, armed services support for R&D in industry increased dramatically, especially in R&D related to specific technologies like radar, aircraft, and synthetic materials. Some military R&D projects that were established in the universities during WW-II were continued with DOD support after 1945, eventually leading to the formation of major university-based research centers and/or stimulating industrial R&D and the formation of new firms. One example was Project Whirlwind, established with Navy funding in 1944 at the Massachusetts Institute of Technology (MIT) to develop a special-purpose computer for use in aircraft trainer/simulators. Whirlwind, continued at MIT by ONR after the war, subsequently led to the establishment of the MIT Computation Center, the MIT Lincoln Laboratory, and the MITRE Corporation; to important advances in software and hardware, including the invention of the magnetic core memory; and to stimulation of industry—especially the rapidly-growing computer industry, including the formation of new firms such as the Digital Equipment Corporation.[7]

According to data collected by the NSF, DOD has historically been the major Federal funder of R&D performed by industry. Although DOD's fraction of all Federal funds for industrially-performed R&D declined sharply in the early 1960s, as R&D support by NASA and other agencies increased, this trend was reversed in the 1970s. During the last two decades, DOD has become increasingly important as a sponsor of R&D in industry, both in absolute terms and also as compared with other Federal supporters of R&D in industry.

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[5] Unless otherwise noted, the term "industrial" as used in this chapter to refer to performers of research and development excludes Federally Funded Research and Development Centers (FFRDCs, formerly known as Federal Contract Research Centers) administered under contract by industrial firms. Various sources of data on DOD funds for R&D treat expenditures in the industrial FFRDCs differently. In FY85, DOD R&D funds to industrially-administered FFRDCs totalled about $105 million, which is equivalent to about one-half of one percent of total DOD R&D funds for industry.

[6] DOD here refers not only to the present-day Department of Defense, established in 1947, but also to its predecessor services and agencies.

[7] For a more complete description of Whirlwind and other seminal DOD-sponsored programs at MIT, see: Return on Investment in Basic Research—Exploring a Methodology. Report to ONR. Bruce S. Old Associates, Inc. November 1981. DTIC No. AD-A-11283.

Table 1 shows that DOD's FY55 obligations of some $0.9 billion for R&D accounted for 93 percent of all Federal support for R&D in industry; by FY67, DOD's obligations of some $5.4 billion accounted for only 55 percent of Federal support for industry R&D. The FY85 figure for DOD R&D spending in industry, nearly $19 billion, reached nearly 87 percent of all Federal funds for R&D performed by industry. About 73 percent of the $34 billion budgeted by DOD for RDT&E in 1985, or $24.3 billion, was earmarked for industry.[8] To put it in another perspective, DOD spending for R&D in industry is equivalent to about eight percent of DOD's total budget.[9]

TABLE 1.—DOD SHARE OF ALL FEDERAL OBLIGATIONS FOR R&D PERFORMED BY INDUSTRY

| Fiscal year: | *Percent* |
|---|---|
| 1955 | 93 |
| 1958 | 91 |
| 1961 | 86 |
| 1964 | 56 |
| 1967 | 55 |
| 1970 | 58 |
| 1973 | 66 |
| 1976 | 64 |
| 1979 | 63 |
| 1982 | 80 |
| 1985 (estimated) | 87 |
| 1986 (estimated) | 89 |

Source: CRS calculations based on data in Table B of Federal Funds for Research and Development. Detailed Historical Tables: Fiscal Years 1955–86. National Science Foundation. Division of Science Resources Studies. Undated. (Hereinafter referred to as NSF Historical Tables.)

DOD has been a major supporter of RDT&E in industry for many years, although its role in industrial basic research has been more limited. Figure 1 shows the DOD share of national expenditures for basic research done in industry, including industry-run FFRDCs, over the period FY1967–84. This share has averaged a little over five percent, ranging from a low of three percent in FY69 to a high of seven percent in FY71 and again in FY80. Figure 2 shows the DOD share of the national expenditures for all R&D done in industry and industry-run FFRDC's from FY67 to 85. From 33 percent in FY67, the DOD share declined steadily to a low of 20 percent in FY79 and 80, then rose to an estimated 30 percent in FY85.[10]

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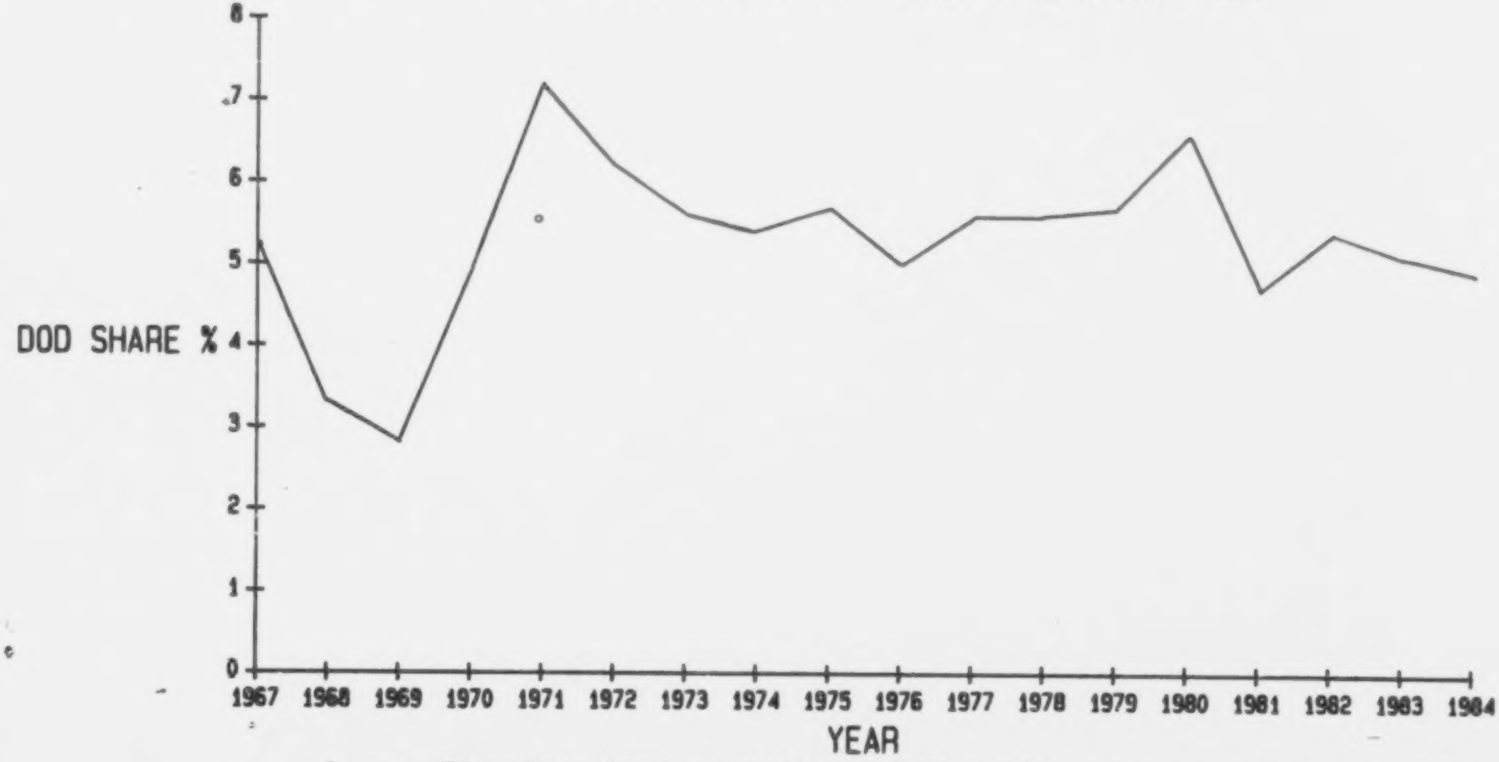
[8] The FY 1985 Dept. of Defense Program for Research, Development, and Acquisition. Statement by the Hon. Richard D. DeLauer, USDRE, to the 98th Congress, Second Session, 1984. Appendix Tables A–4, A–7.

[9] These Federal funds data for RDT&E do not include DOD overhead payments to industry on procurement contracts that are intended as partial reimbursement for "Independent Research and Development" (IR&D). These payments totaled about $1.9 billion in FY84. (See Chapter VIII for details about IR&D.)

[10] CRS calculations from data in NSF Historical Tables and in Science Indicators 1985.

## FIGURE 1

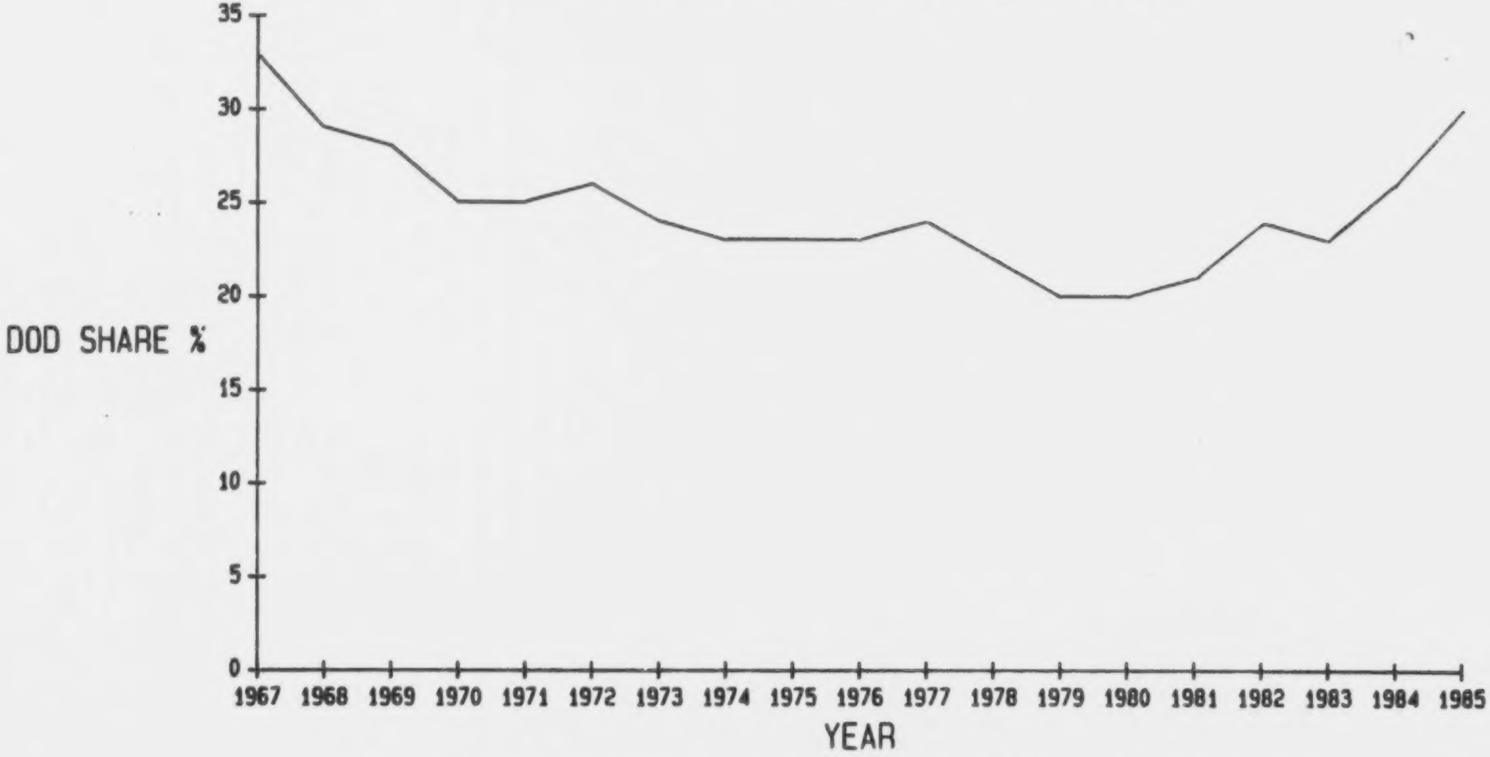
## DOD SHARE OF INDUSTRIAL BASIC RESEARCH FUNDS



Source: CRS estimates based on data in NSF Historical Tables and in Science Indicators, 1985

FIGURE 2

DOD SHARE OF ALL INDUSTRIAL R&D FUNDS



Source: CRS estimates based on data in NSF Historical Tables and in Science Indicators, 1985

## C. DOD STRUCTURE AND ORGANIZATION FOR RDT&E IN INDUSTRY[11]

The entire DOD budget is divided into ten accounting categories, the sixth of which is the RDT&E portion of the budget, or Budget Category 6. This budget category for RDT&E activities is further subdivided as follows: Research, 6.1; Exploratory Development, 6.2; Advanced Development, 6.3; Engineering Development, 6.4; and Management and Support of R&D, 6.5. RDT&E activities related to military systems that are already operational (i.e., in use in the field) are grouped together and referred to as budget category 6.6, Operational Systems Development.[12] The sum of categories 6.1 and 6.2 is often referred to as the "Technology Base."

The DOD budget typology defines the vertical organization of the DOD RDT&E program. The organization reflects, in turn, the classical "linear pipeline" model of the evolution of new technologies, as evidenced by the emphasis DOD places upon Research (6.1) as the "obvious foundation for the whole (RDT&E) process."[13] Following on the use of the linear pipeline model, new concepts are said to enter the DOD RDT&E system at the Research (6.1) level. Successful completion of a 6.1 program frequently leads to Exploratory Development (6.2); i.e., to applied research in which the proven concept is used in or applied to a device that has a potential military application. In the Advanced Development (6.3) stage, a prototypical product is developed for further testing and evaluation. Finally, Engineering Development (6.4) reconfigures successful prototypes in preparation for production, should circumstances require.[14]

In keeping with the linear pipeline model, RDT&E management places great emphasis on transferring, or "transitioning" projects from one category to another (e.g., from 6.3 to 6.4), with the explicit assumption that better management will result in more Technology Base projects evolving into Engineering Development programs and, ultimately, becoming candidates for operational systems. As in most research and development organizations based on the pipeline model, problems arise in connection with such transfers, since they typically involve transfer between responsible organizational units in DOD and between contractors, as well as transfers between budget categories. The problems arise because programs are managed differently and are performed by different entities as they move from one budget category to the next.[15]

In FY85, half of the extramural work budgeted for support by DOD under budget category 6.1 was done by university-based performers and another 30 percent was performed in government laboratories. DOD has estimated that 20 percent of the 6.1 budget is for work performed by industry and all of the FFRDCs.[16] NSF data suggests that only about 10% of 6.1 funds, or $86 million, was spent in industry in FY85.[17]

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[11] This chapter uses "R&D" and "RDT&E" interchangeably unless a distinction is made explicit.

[12] Strictly speaking, 6.6 is not a Program 6 budget account. Instead, it represents an aggregate of R&D-like expenditures related to operational systems whose costs are scattered throughout other major categories of DOD's procurement budget.

[13] Basic Research Program, DOD. September 1985. p. 4. Some DOD activities that might otherwise be considered "test or evaluation" are not included in Budget Category 6, including routine testing of components or systems in the field. Test and evaluation refers, instead, to such activities in connection with new concepts and systems.

[14] Ibid.

[15] See, for example, Ronald G. Havelock and David S. Bushnell, Technology Transfer at DARPA: A Diagnostic Analysis, report of the Technology Transfer Study Center, George Mason University, December 1985. 79 pages.

Industry performers of 6.1 programs tend to follow project selection and administrative procedures developed for university performers. An exception is that competitively-bid contracts are more prevalent for industry performers than for universities. According to DOD, the 6.1 research performed by industry tends to be more near-term and more closely related to the mission requirements of the sponsoring military laboratory than is the 6.1 research performed in universities.

Most 6.1 programs are administered by the service laboratories, including the Army Research Office, ARO; the Office of Naval Research, ONR; and the Air Force Office of Scientific Research, AFOSR, and by DARPA's Defense Sciences Office, DSO. The Office of Research and Laboratory Management in the Office of the Secretary of Defense oversees the 6.1 Research program, and also oversees contractors' IR&D activities.

In general, industry contracts for programs in categories 6.2 and 6.3A (which, along with 6.1, constitute the DOD "Science and Technology Program") are administered by the Services and by DARPA. Guidance at the level of the OSD is provided for these programs through four directorates in the Office of the Undersecretary of Defense for Research and Engineering (OUSDRE): Environment and Life Sciences, Military Systems Technology, Very High Speed Integrated Circuits (VHSIC), and Computer and Software Systems.

Most programs in budget categories 6.3 and higher are carried out by industrial performers. Programs in budget category 6.3B are very similar to 6.4 programs, which (like 6.5 and 6.6 programs) are administered on a project basis by the Services.

In terms of the DOD systems acquisition cycle, activities categorized as 6.1 or 6.2 occur in the "conceptual" phase before DSARC Milestone I.[18] Category 6.3 activities are initiated in the conceptual phase and continue through the end of the "validation" phase (Milestone II). Next, 6.4 activities begin after Milestone II, when the "full scale development" phase takes place (Milestone IIa marks the transition from engineering development to development of the production prototype in this phase). Procurement-related funds (6.6) cover production-prototype work and continue through production and deployment (after Milestone III). Management and support (6.5) activities take place throughout this process.[19]

In Chapter IV it was shown that the composition of the DOD "RDT&E" budget is more heavily devoted to "downstream" development work than to basic or applied research. The composition of funds for DOD-sponsored RDT&E performed by industry reflects this overall allocation. Table II shows that the fraction of all DOD funds for RDT&E in industry that is directed toward development goals has been around 90 percent for at least two decades, and that it has risen to 95 percent in recent years.

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[16] Department of Defense Basic Research Program. Presented by Leo Young, Director, Research and Laboratory Management, at the R&D Colloquium of the American Association for the Advancement of Science, Washington, D.C., April 3, 1985.

[17] CRS estimates from data in NSF Historical Tables, tables 26B and 28B through 34B.

[18] The DSARC milestones are described in Chapter IV.

[19] Defense RDT&E Planning and Strategy Parameters: Methodological Considerations. Ronald C. Wakefield, et al. Prepared for DARPA. Stanford Research Institute. December 1974. p. 130. DTIC No. AD–A030761.

TABLE II.—COMPOSITION OF DOD FUNDS FOR RDT&E PERFORMED BY INDUSTRY

[In billions of current dollars]

| | Funds for all RDT&E | Funds for development only (6.3-6.6) | Percentage of funds for development |
|---|---|---|---|
| Fiscal year: | | | |
| 1967 | $5.4 | $4.8 | 89 |
| 1970 | 4.5 | 4.1 | 91 |
| 1973 | 5.1 | 4.7 | 92 |
| 1976 | 6.0 | 5.5 | 91 |
| 1979 | 7.7 | 6.9 | 90 |
| 1982 | 13.8 | 12.6 | 91 |
| 1985 (estimated) | 23.0 | 21.9 | 95 |

Source: CRS calculations from data in NSF Historical Tables, Tables 10A, B and 49A, B. Excludes FFRDCs.

As shown in Table III, DOD has markedly increased its share of all Federally-funded *development* performed by industry, from 55 percent in 1967 to 92 percent in 1985. At the same time, its share of all federally-funded *research* performed by industry has remained relatively constant.

TABLE III.—DOD SHARE OF ALL FEDERAL OBLIGATIONS FOR R&D PERFORMED BY INDUSTRY (EXCLUDES FFRDCs)

[In percent]

| | DOD share of Federal obligations for basic and applied research | DOD share of Federal obligations for development |
|---|---|---|
| Fiscal year: | | |
| 1967 | 56 | 55 |
| 1970 | 48 | 60 |
| 1973 | 50 | 69 |
| 1976 | 47 | 67 |
| 1979 | 43 | 67 |
| 1982 | 57 | 84 |
| 1985 (estimated) | 54 | 92 |

Source: CRS calculations from data in NSF Historical Tables, Tables 29A, B; 39A, B; and 49A, B.

Despite the fact that over 90 percent of DOD's spending for RDT&E performed in *industry* is for development purposes, DOD is a major Federal supporter of basic and applied research by *all* performers; its share was 34 percent in FY67. DOD's share fell to a low of 19 percent by FY79, rose to 23 percent in FY82, and is estimated to be about 21 percent in FY85.[20] Corresponding DOD shares of Federal obligations for development by *all* performers are 54 percent in FY67, 60 percent in FY82, and an estimated 85 percent in FY85.[21]

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[20] CRS calculations from NSF Historical Tables, Table A.

[21] Ibid.

The various military services have different management structures and styles for RDT&E. For example, the Army places a relatively higher reliance on in-house ("intramural") expertise than do the other services. The Navy has a highly centralized R&D management structure. The Air Force has the least centralized R&D management structure and the smallest amount of intramural RDT&E work.[22] To illustrate these contrasts, Table IV shows how the pattern of intramural/industrial/other performance of DOD R&D differs by Service. It is interesting to note that spending by the Defense agencies has grown by far the most rapidly in relative terms over the two decades shown, and that they have spent a sharply decreasing fraction of their funds outside the DOD laboratories and industry over that period.

TABLE IV.—PATTERNS OF RDT&E PERFORMANCE BY MILITARY SERVICE AND AGENCY

[Current dollars in billions, shares in percent] [1]

| | Fiscal year— | | | |
|---|---|---|---|---|
| | 1964 | 1974 | 1984 | 1985 (estimate) |
| Total R&D/RDT&E: | | | | |
| DOD | $7.87 | $8.42 | $27.54 | $34.14 |
| Army [2] | 1.46 | 2.00 | 4.45 | 5.12 |
| Navy | 1.57 | 2.72 | 7.53 | 9.72 |
| Air Force | 3.79 | 3.22 | 12.76 | 14.70 |
| Defense Agencies [3] | .28 | .45 | 2.73 | 4.51 |
| Intramural performers (shares in percent): | | | | |
| DOD | 24 | 31 | 28 | 25 |
| Army | 32 | 35 | 40 | 37 |
| Navy | 41 | 35 | 29 | 27 |
| Air Force | 11 | 25 | 20 | 16 |
| Defense Agencies | 8 | 31 | 38 | 36 |
| Industry performers (shares in percent): | | | | |
| DOD | 67 | 61 | 64 | 67 |
| Army | 60 | 61 | 53 | 56 |
| Navy | 49 | 57 | 63 | 66 |
| Air Force | 79 | 68 | 72 | 76 |
| Defense Agencies | 57 | 45 | 52 | 58 |
| Other performers [1] (shares in percent): | | | | |
| DOD | 9 | 8 | 8 | 8 |
| Army | 8 | 4 | 7 | 7 |
| Navy | 10 | 8 | 8 | 7 |
| Air Force | 10 | 7 | 8 | 8 |
| Defense Agencies | 35 | 24 | 10 | 6 |

[1] The residual is performed by universities, other nonprofit institutions, and FFRDCs.
[2] Military functions only; excludes Corps of Engineers.
[3] FY64 data are only for ARPA (Advanced Research Projects Agency).

Source: CRS calculations from obligations data in NSF Historical Tables, Tables 7A/B; 9A/B; 10A/B (FY74 and FY84, 85) and NSF64-11, p. 118 (FY64). Industry data excludes FFRDCs.

## D. TECHNOLOGY BASE WORK PERFORMED BY INDUSTRY

DOD does not routinely employ the categories "basic research" or "applied research" in its budgeting and program management. The National Science Foundation, however, in its reporting of Federal funds for R&D, uses a typology that equates DOD budget category 6.1 (Research) with NSF's basic research and DOD budget category 6.2 (Exploratory Development) with NSF's applied research. These two budget categories together constitute the DOD "Technology Base." Technology-base appropriations for FY87 are approximately $3.3 billion, or just over 9 percent of the total RDT&E appropriation, with 6.1 alone accounting for about 2.6 percent of the RDT&E appropriation.[23]

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[22] Robert Perry characterizes the Services' styles of R&D management as "arsenal" for the Army, "bureau" for the Navy, and "contract" for the Air Force. For a discussion of U.S. military R&D styles contrasted with the Soviet model, see: American Styles of Military R&D. Robert Perry. The RAND Corporation, RAND Paper Series. June 1979. DTIC No. AD-090089.

Figures 3 and 4 show the dollar amounts and shares of the DOD Technology Base performed by industry for FY67 through FY85.[24] Table V shows the relative proportions of Technology Base work performed in industry for the Services and agencies in recent years. The Air Force has the largest shares of both its total RDT&E (see Table IV) and its Technology Base work performed by industry.

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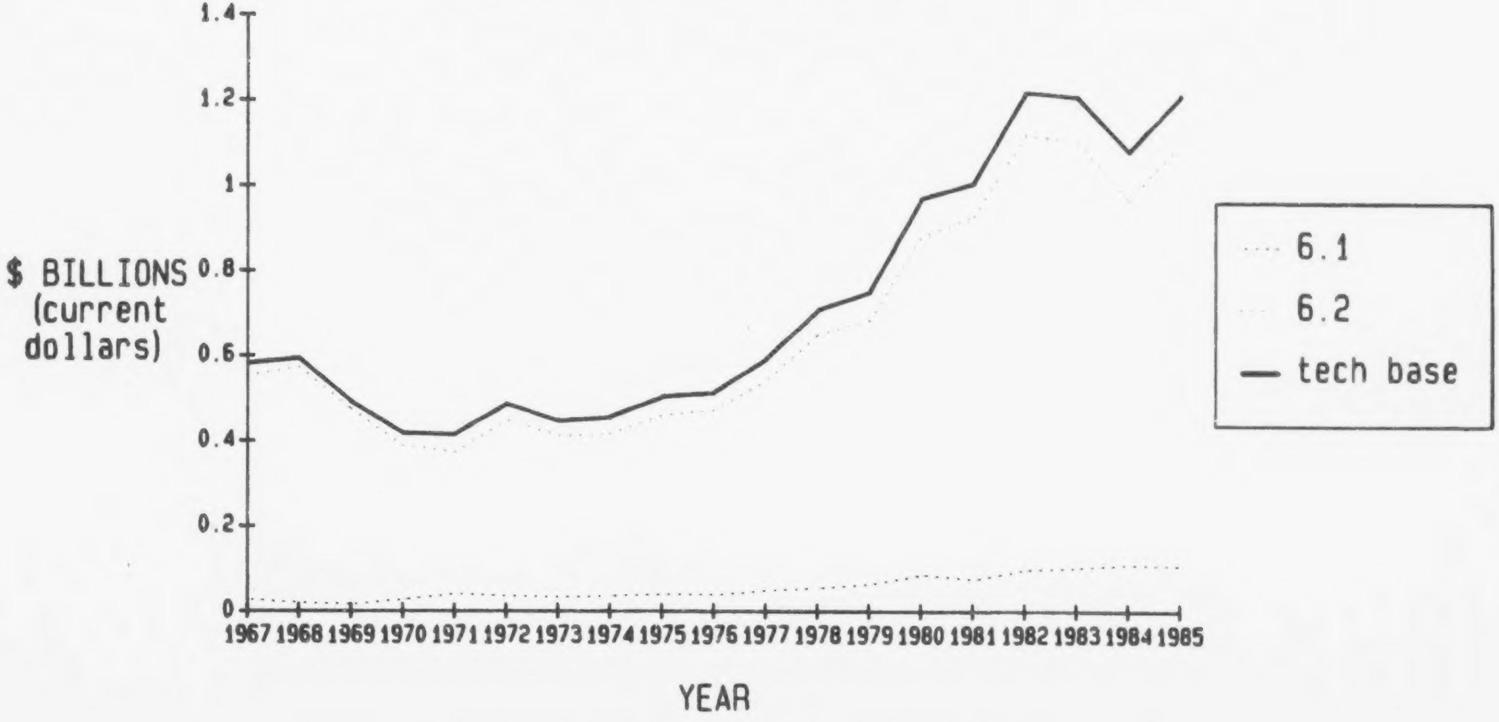
[23] CRS estimates based on data in Defense Daily, Oct. 23, 24, 27, and 28, 1986.

[24] These shares were calculated for NSF Federal funds (obligations) data, so they differ slightly from DOD (budget estimate) data.

FIGURE 3

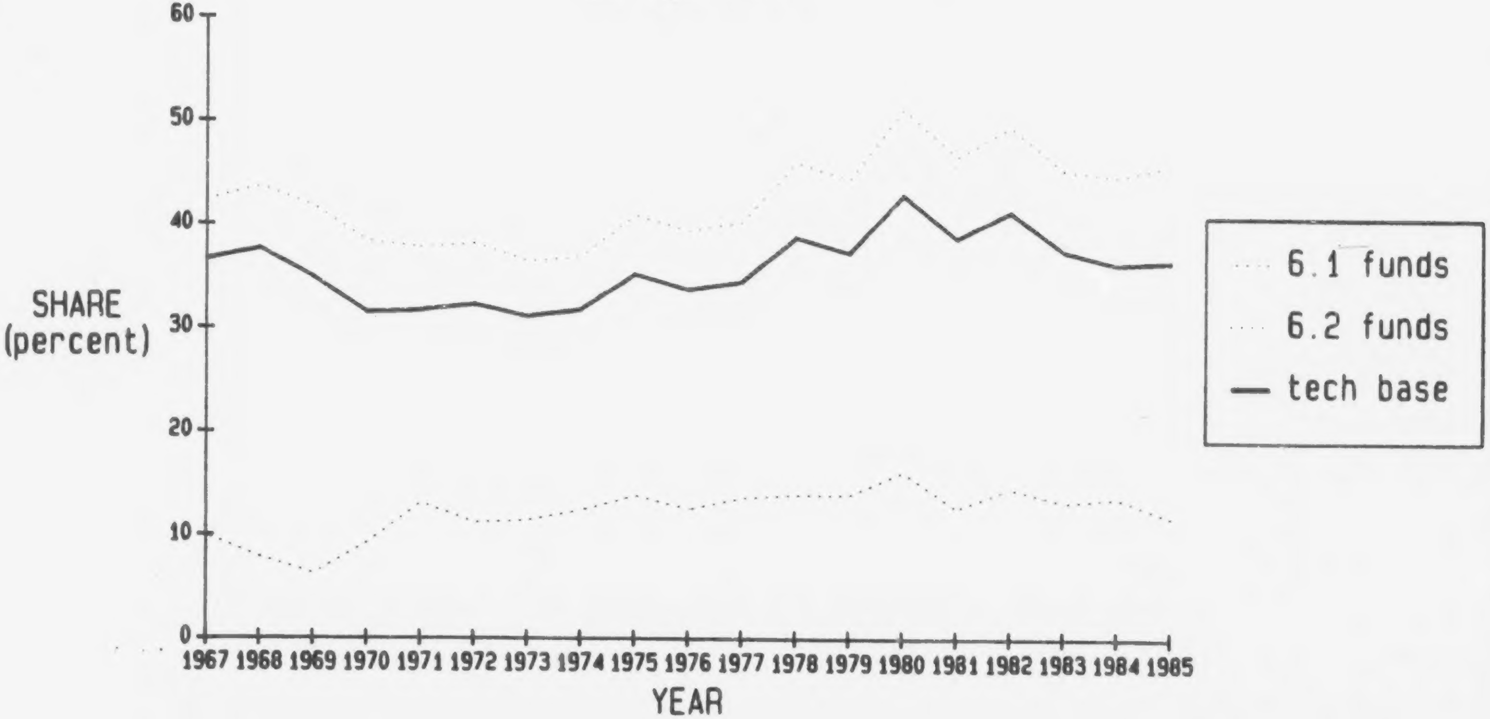
OBLIGATIONS FOR DOD TECHNOLOGY BASE
(to industrial performers)



Source: CRS estimates based on data in NSF Historical Tables

FIGURE 4

INDUSTRIAL PERFORMER SHARES OF TECHNOLOGY BASE
(obligations)



Source: CRS estimates based on data in NSF Historical Tables

TABLE V.—SHARES OF COMPONENTS OF TECHNOLOGY BASE PERFORMED IN INDUSTRY

[In percent]

| | Fiscal year— | |
|---|---|---|
| | 1984 (estimate) | 1985 (estimate) |
| Basic Research (6.1): | | |
| All DOD | 14 | 12 |
| Army | 8 | 11 |
| Navy | 12 | 9 |
| Air Force | 16 | 16 |
| Defense Agencies | 24 | 14 |
| Applied Research (6.2): | | |
| All DOD | 45 | 43 |
| Army | 28 | 32 |
| Navy | 26 | 26 |
| Air Force | 57 | 60 |
| Defense Agencies | 56 | 48 |

Source: CRS calculations from obligations data in NSF Federal Funds for R&D (NSF 84-336), Tables C-35,36,54,55. Excludes FFRDCs.

## E. Industrial RDT&E Performance and the Role of RDT&E in Industry

DOD RDT&E performed by industry is presumably linked to DOD mission needs and to DOD's perceptions of current, emerging, and potential military threats. Although performers are selected competitively for Technology Base programs primarily on the basis of their technical competence or in order to establish or enhance a particular capability in a sector—the military laboratories, for example—the bulk of the "development" (DOD budget categories 6.3-6.6) is closely tied to military procurement. Thus, these downstream RDT&E awards are tied more closely to contractors' ultimate production contracts. Furthermore, because they are tied to identifiable components and systems, the details of development projects are typically classified, whereas much of the 6.1 research program is not.

A movement away from the arsenal system of military systems development and manufacturing began during WW-II and accelerated throughout the 1950s and 1960s. Simultaneously, military hardware became more complex and dependent on electronic and computer technologies. Government-owned arsenals were largely supplanted by industrial contractors. Earlier, these contractors tended to be aircraft or shipbuilding firms. Today, large, conglomerate prime contractors that operate in multiple industrial sectors and have customers in the defense, space, and civilian sectors, such as Rockwell International and General Electric, dominate the "defense industry".

Although the number of defense contractors throughout this evolution has been large and growing, the "defense market", especially the "defense R&D market", in specific areas of technology and in specific weapons or systems is typically quite concentrated, particularly among the largest prime contractors.

DOD regularly publishes a list of the "Top 100" prime procurement contractors [25] and a second list of the "Top 500" prime RDT&E contractors.[26] These lists include contract dollar amounts and procurement categories, along with data on all of the remaining major prime contracts. Tables VI and VII summarize the scope and composition of the major RDT&E prime contract activity over the period FY64-84.[27]

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[25] DOD, Office of the Secretary of Defense, Directorate for Information Operations and Reports, 100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards, [various fiscal years]. (Hereinafter, Top 100 Contractors [year]).

[26] DOD, Office of the Secretary for Defense, Directorate for Information Operations and Reports, 500 Contractors Receiving the Largest Dollar Volume of Prime Contract Awards for RDT&E [various fiscal years]. (Hereinafter, Top 500 RDT&E Contractors [year]).

[27] The Top 500 RDT&E Contractors report does not report RDT&E subcontracts. A prime contractor may subcontract portions of an RDT&E contract to other performers, which may increase the diversity of RDT&E performers and may increase the number of small and/or new firms that participate in DOD RDT&E activity. Offsetting this tendency toward diversity is the fact that a substantial portion of RDT&E subcontract awards is made to firms that are prime contractors on other major RDT&E contracts.

16A

### TABLE VI.

Trends in Scope of Major Prime RDT&E Contracts*

| | FY64 | FY69 | FY74 | FY79 | FY84 |
|---|---|---|---|---|---|
| Total Number of Contractors Receiving Major Prime RDT&E Contracts | 1,727 | 1,950 | 1,976 | 1,950 | 2,033 |
| Total Dollar Value of Major Prime RDT&E Contract Awards (million current dollars) | 5,813 | $6,013 | 5,815 | 8,543 | 18,277 |
| Total Dollar Value of Major Prime RDT&E Contract Awards to Top 500 RDT&E Contractors (million current dollars) | 5,725 | 5,910 | 5,708 | 8,378 | 17,958 |
| Share of Major Prime RDT&E Contract Dollars to Top 500 RDT&E Contractors (percent) | 98.5 | 98.3 | 98.2 | 98.1 | 98.3 |

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*"Major" is a prime contract award of $10,000 or more in FY64, FY69, FY74, and of $25,000 or more for FY84.

Source: Top 500 RDT&E Contractors, for years shown.

TABLE VII.

Trends in Numbers of Major Prime RDT&E Contractors

| | FY64 | FY69 | FY74 | FY79 | FY84 |
|---|---|---|---|---|---|
| Composition of Top 500 RDT&E Contractors | | | | | |
| U.S. Business Firms | 370 | 349 | 384 | 368 | 382 |
| Nonprofit Institutions* | 127 | 146 | 111 | 127 | 116 |
| Foreign Contractors | 3 | 5 | 5 | 5 | 2 |
| Small Businesses | | | | | |
| Receiving Major Prime RDT&E Contract Awards | 784 | 951 | 1,071 | 1,133 | 1,196 |
| In Top 500 RDT&E Prime Contractors | 136 | 127 | 179 | 186 | 192 |
| Nonprofit Institutions | | | | | |
| Receiving Major Prime RDT&E Contract Awards | 340 | 365 | 331 | 329 | 327 |
| In Top 500 RDT&E Prime Contractors | 127 | 146 | 111 | 127 | 116 |
| Foreign Contractors | | | | | |
| Receiving Major Prime RDT&E Contract Awards | 107 | 97 | 54 | 42 | 76 |
| In Top 500 RDT&E Prime Contractors | 3 | 5 | 5 | 5 | 2 |

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*Nonprofits include educational institutions, Government agencies, and other nonprofit institutions.

Source: Top 500 RDT&E Contractors, for years shown.

Although the number of U.S. firms receiving major [28] RDT&E contract awards has grown by some 18 percent over the past twenty years, most of the increase has been to firms with small contracts. The Top 500 RDT&E performers, overwhelmingly firms rather than universities and nonprofits, have consistently received over 98 percent of the dollar value of prime contracts awarded to the approximately 2000 performers of major RDT&E contracts. In FY64, based on some $5.8 billion in major prime contract awards to 1,727 RDT&E contractors, each contractor received, on average, awards totaling approximately $3.4 million. In that year, the 114th-ranked prime RDT&E contractor (Southwest Research Institute) received approximately this average amount, while the first-ranked contractor (Lockheed) received awards amounting to some $548 million, or about 170 times the average amount.[29] In FY84, 2033 contractors received some $18.3 billion in major prime RDT&E contracts, with average awards to each contractor totaling about $9 million. In FY84, the 136th-ranked contractor (HRB-Singer, Inc.) received approximately this average amount, while the first-ranked RDT&E contractor (Boeing) received awards totalling nearly $1.8 billion, or about 200 times the average contract amount.[30]

Of the $18.3 billion awarded for major prime RDT&E contracts in FY84, 84 percent went to large U.S. firms, five percent to small firms, and nearly 12 percent to universities and nonprofits.[31] More recent data show that RDT&E awards in FY85 totaled some $18.9 billion, with about 38 percent of that amount going for work related to missiles and space systems and about 25 percent for work related to electronics and communications.[32]

Table VIII lists the top ten prime RDT&E contractors for selected years from 1964 to 1985. Although there is some turnover in the Top 500 RDT&E rankings, as well as in the top ten, major contractors such as Boeing, General Dynamics, and Rockwell have tended to remain top RDT&E performers over this twenty-year period. In large part, this results from the strong linkages between RDT&E performance and systems procurement. Table IX shows the areas of application in which major contracts for RDT&E have been concentrated. These application areas for RDT&E are also major categories of DOD systems procurement.

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[28] "Major" contracts involve awards of $10,000 or more for FY64 through FY82, and of $25,000 or more thereafter.

[29] Top 500 RDT&E Contractors FY64.

[30] Top 500 RDT&E Contractors FY84.

[31] Ibid.

[32] Defense Daily. April 2, 1986: 180.

### TABLE VIII.—TOP TEN RDT&E PRIME CONTRACTORS

| | FY1964 | | FY1969 |
|---|---|---|---|
| 1 | North American Aviation Inc.[1] | 1 | Lockheed Aircraft Corp.[2] |
| 2 | General Dynamics Corp. | 2 | Western Electric Co., Inc. |
| 3 | Lockheed Aircraft Corp. | 3 | General Electric Co. |
| 4 | Western Electric Co., Inc. | 4 | McDonnell Douglas Corp. |
| 5 | Boeing Co. | 5 | Boeing Co. |
| 6 | Martin Marietta Corp. | 6 | North American Rockwell Corp. |
| 7 | General Electric Co. | 7 | General Dynamics Corp. |
| 8 | Aerojet General Corp. | 8 | United Aircraft Corp. |
| 9 | United Aircraft Corp. | 9 | Hughes Aircraft Corp. |
| 10 | Pan American World Airways Inc. | 10 | Grumman Aircraft Engineering Co. |

[1] North American Aviation became North American Rockwell, which became Rockwell International.

[2] Lockheed Aircraft became Lockheed Missiles and Space.

Source: Top 500 RDT&E Contractors, for years shown.

| | FY1974 | | FY1979 |
|---|---|---|---|
| 1 | Rockwell International Corp. | 1 | McDonnell Douglas Corp. |
| 2 | General Electric Co. | 2 | Boeing Co. |
| 3 | Boeing Co. | 3 | General Dynamics Corp. |
| 4 | McDonnell Douglas Corp. | 4 | Hughes Aircraft Co. |
| 5 | Lockheed Missiles and Space Co., Inc. | 5 | General Electric Co. |
| 6 | Raytheon Co. | 6 | Rockwell International Corp. |
| 7 | General Dynamics Corp. | 7 | Raytheon Co. |
| 8 | Western Electric Co., Inc. | 8 | Martin Marietta Corp. |
| 9 | Hughes Aircraft Co. | 9 | TRW Inc. |
| 10 | United Aircraft Co. | 10 | Lockheed Missiles and Space Co., Inc. |

| | FY1984 | | FY1985 |
|---|---|---|---|
| 1 | Boeing Co. | 1 | Lockheed Missiles and Space Co., Inc. |
| 2 | Lockheed Missiles and Space Co., Inc. | 2 | Boeing Co. |
| 3 | Rockwell International Corp. | 3 | Martin Marietta Corp. |
| 4 | General Electric Co. | 4 | General Electric Co. |
| 5 | Martin Marietta Corp. | 5 | McDonnell Douglas Corp. |
| 6 | General Dynamics Corp. | 6 | Rockwell International Corp. |
| 7 | McDonnell Douglas Corp. | 7 | IBM |
| 8 | Hughes Aircraft Co. | 8 | Westinghouse Electric Corp. |
| 9 | Westinghouse Electric Corp. | 9 | General Dynamics Corp. |
| 10 | TRW | 10 | Hughes Aircraft Co. |

### TABLE IX.—MAJOR RDT&E CONTRACTOR ACTIVITIES BY AREA OF APPLICATION

| Fiscal year and areas of application: | *Percent*[1] |
|---|---|
| 1964—Missiles, aircraft, ships, electronics | 88.3 |
| 1969—Missiles and space, electronics, aircraft | 81.9 |
| 1974—Missiles and space, electronics, aircraft | 76.6 |
| 1979—Missiles and space, electronics and communications, aircraft | 73.4 |
| 1984—Missiles and space, electronics and communications, aircraft | 78.0 |

[1] Percentage of contract dollars awarded in areas of application.

Source: Top 500 RDT&E Contractors, various years.

Not surprisingly, the top RDT&E contractors also rank among the top recipients of DOD prime procurement contracts, since the firms' own work (including IR&D, see Chapter VIII) and their DOD-funded RDT&E contracts enhance their ability to compete for systems procurement contracts.[33] Table X lists DOD's top ten prime procurement contractors for FY81 and FY84, and Table XI shows the composition of the Top 100 prime contractors according to the procurement categories that account for the largest dollar value of each firm's contracts.

### TABLE X.—TOP 10 DOD PRIME PROCUREMENT CONTRACTORS

[Awards in billions]

| *Rank order and company* | *Awards* |
|---|---|
| Fiscal year 1981: | |
| 1—McDonnell Douglas Corp. | $4.4 |
| 2—United Technologies Corp. | 3.8 |
| 3—General Dynamics Corp. | 3.4 |
| 4—General Electric Co. | 3.0 |
| 5—Boeing Co. | 2.7 |
| 6—Lockheed Corp. | 2.7 |
| 7—Hughes Aircraft Co. | 2.6 |
| 8—Raytheon Co. | 1.8 |
| 9—Grumman Corp. | 1.7 |
| 10—Chrysler Corp. | 1.4 |
| Fiscal year 1984: | |
| 1—McDonnell Douglas | 7.7 |
| 2—Rockwell International Corp. | 6.2 |
| 3—General Dynamics Corp. | 6.0 |
| 4—Lockheed Corp. | 5.0 |
| 5—Boeing Co. | 4.6 |
| 6—General Electric Co. | 4.5 |
| 7—Howard Hughes Medical Inst.[1] | 3.2 |
| 8—United Technologies Corp. | 3.2 |
| 9—Raytheon Co. | 3.1 |
| 10—Litton Industries Inc. | 2.4 |

[1] Owner of Hughes Aircraft in 1984.

Source: Top 100 Contractors, 1981 and 1984.

### TABLE XI.—NUMBER OF TOP 100 DOD PRIME CONTRACTORS ACTIVE IN EACH PROCUREMENT CATEGORY

| | Fiscal year— | |
|---|---|---|
| | 1981 | 1984 |
| Aircraft | 16 | 14 |
| Missiles | 15 | 13 |
| Ships | 6 | 6 |
| Tank-Automotive | 7 | 7 |
| Ammunition | 5 | 8 |
| Electronics | 17 | 21 |
| Services | 6 | 8 |
| Construction | 3 | 2 |
| Petroleum | 24 | 17 |
| Weapons | 0 | 2 |
| Subsistence | 0 | 0 |
| Other | 1 | 2 |
| Total | 100 | 100 |

Source: Top 100 Contractors, 1981 and 1984.

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[33] Winning RDT&E contracts is often alleged to be a way of "buying-in" to lucrative, long-term procurement contracts.

In FY84, the top five procurement contractors accounted for 22 percent of the total of $133.6 billion in major prime procurement contracts awarded that year, and the Top 100 prime contractors accounted for 69 percent of this amount. By comparison, the RDT&E market is more concentrated than the general procurement market. In FY84, while the top 10 prime procurement contractors received 34 percent of the major contract award, the top ten prime RDT&E contractors garnered 46 percent of the major RDT&E contract awards. RDT&E performed by industry is geographically concentrated as well. For example, Malecki showed that industrially-performed RDT&E is concentrated in ten states, which receive 76 percent of these funds.[34]

Table XI's breakdown of DOD major prime procurement contract activity by procurement category for FY81 and FY84 shows that the bulk of the Top 100 procurement contractors' revenues came from such R&D-intensive categories as aircraft, missiles, and electronics. Table XII presents the distribution of major RDT&E contract awards in these fiscal years, broken down by type of activity (according to the DOD Budget Category typology) and by area of application.

TABLE XII.—DISTRIBUTION OF RDT&E CONTRACT AWARDS BY BUDGET CATEGORY AND AREA OF APPLICATION

| | Fiscal year 1981 | | Fiscal year 1984 | |
|---|---|---|---|---|
| | Millions | Percent of total | Millions | Percent of total |
| Budget Category: | | | | |
| Engineering Development (6.4) | $4,807 | 45.9 | $10,154 | 55.6 |
| Advanced Deveopment (6.3) | 2,130 | 20.3 | 2,542 | 13.9 |
| Operational Systems Development (6.6) | 1,296 | 12.4 | 2,919 | 16.0 |
| Exploratory Development (6.2) | 1,081 | 10.3 | 1,246 | 6.8 |
| Research (6.1) | 694 | 6.6 | 957 | 5.2 |
| Management and Support (6.5) | 474 | 4.5 | 459 | 2.5 |
| Total | 10,482 | 100.0 | 18,277 | 100.0 |
| Area of Application: | | | | |
| Missiles and Space Systems | 4,603 | 43.9 | 7,296 | 39.9 |
| Electronics and Communication Equipment | 2,581 | 24.6 | 4,644 | 25.4 |
| Services | 1,474 | 14.1 | 2,088 | 11.4 |
| Aircraft | 739 | 7.1 | 2,316 | 12.7 |
| Ships | 293 | 2.8 | 662 | 3.6 |
| Weapons | 253 | 2.4 | 564 | 3.1 |
| Ammunition | 208 | 2.0 | 297 | 1.6 |
| Tank-Automotive | 150 | 1.4 | 137 | .7 |
| Other | 180 | 1.7 | 273 | 1.5 |
| Total | 10,482 | 100.0 | 18,277 | 100.0 |

Source: Top 500 Contractors, 1981 and 1984.

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[34] Malecki, Edward J. Federal and Industrial R&D: Locational Structures, Economic Effects and Inter-relationship. Dept. of Geography. U. of Oklahoma, 1983. p. 88–126. The ten states are California, Massachusetts, Missouri, Florida, Washington, New York, Maryland, Kansas, Virginia, and Texas. Malecki also found that over half of the *intramural* R&D was performed in only five States (California, Maryland, Ohio, Virginia, and New Jersey).

An alternative typology used by DOD to categorize the RDT&E budget is based on the purposes served by the RDT&E activities. It divides the budget authority among these activities: Technology Base, Advanced Technology Development, Strategic Programs, Tactical Programs, Intelligence and Communications, and Defensewide Mission Support.[35] Table XIII shows the composition of FY81 and FY84 total DOD RDT&E obligations to all performers, including DOD laboratories, broken out according to the Budget Activity typology. For comparison, Table XIV shows the compositon of total DOD RDT&E by budget category for the same fiscal years.

TABLE XIII.—COMPOSITION OF DOD RDT&E BY PURPOSE OF BUDGET ACTIVITY

[In percent]

| Activity | Fiscal year— | |
|---|---|---|
| | 1981 | 1984 |
| Technology Base | 16 | 11 |
| Advanced Technology Development | 4 | 5 |
| Strategic Programs | 19 | 28 |
| Tactical Programs | 36 | 30 |
| Intelligence and Communication | 9 | 12 |
| Defense-wide Mission Support | 16 | 14 |
| Total | 100 | 100 |
| Total obligations (billions) | $16.5 | $27.6 |

Note.—The percentages shown in this table, calculated from obligations data in Special Analysis K of the President's budget, differ slightly from those calculated from DOD budget data.

Source: CRS calculations from DOD obligations data reported in Special Analysis K, FY83 and FY85, Table K–5.

TABLE XIV.—COMPOSITION OF DOD RDT&E BY BUDGET CATEGORY

[In percent]

| Category | Fiscal year— | |
|---|---|---|
| | 1981 | 1984 |
| Techonogy Base (6.1 and 6.2) | 16 | 11 |
| Advanced Development (6.3) | 17 | 22 |
| Engineering Development (6.4) | 38 | 34 |
| Management and Support (6.5) | 10 | 9 |
| Operational Systems Development (6.6) | 19 | 24 |
| Total | 100 | 100 |
| Total budget (billions) | $16.6 | $26.9 |

Source: CRS calculations from DOD budget data reported in DOD Basic Research, 1984, p. 1 and 1985, p. 1.

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[35] The annual DOD budget (R–1), for example, uses both typologies to break out the RDT&E budget.

The portion of RDT&E devoted to the Technology Base decreased from 1981 to 1984, and this trend continued in the FY85 and FY86 RDT&E budgets. In FY85 and FY86, according to DOD budget figures, while Technology Base funds increased in (current) dollar terms, their share of total RDT&E fell to 10 percent, then 9 percent, of those years' budgets. Category 6.3, on the other hand, increased markedly as a percentage of the RDT&E budget, amounting to about 30 percent in FY86. In part, this reflects increased funding for the Strategic Defense Initiative (SDI), which for management purposes is categorized as a 6.3 activity despite the fact that the SDI program encompasses a broader range of RDT&E activities. It is likely that the shifts in composition of the RDT&E budget away from the technology base and toward more mature projects, as well as toward systems and strategic programs, will bring industry into even greater prominence as an RDT&E performer, despite the well-publicized increases for university support by DOD discussed in other chapters of this report.

## F. Four DOD Industrial RDT&E Initiatives

In keeping with the focus of this report on DOD support of research, as opposed to development, test, and evaluation, the remainder of this chapter describes four special DOD initiatives that involve industrial RDT&E performers in attempts to make major advances in the state of the art of science and techology that may be the basis for entire new families of defense technologies or that may lead to significant cost reductions in their production. The four initiatives are: the Small Business Innovation Research Program (SBIR), the Manufacturing Technology Program (ManTech), the Strategic Computing Initiative (SCI), and the Very High Speed Integrated Circuit (VHSIC) Program. Each initiative has different goals and follows different styles of management and organization.

The Strategic Computing Initiative and the Very High Speed Integrated Circuits Program are both intended to advance the state of the art in technical capabilities underlying families of new technology. SCI is focused on artificial intelligence applications and advanced computing technologies, and VHSIC on high-speed, large-scale, temperature-resistant, radiation-hardened, silicon-based, integrated circuit microchips. ManTech is a program intended to assist contractors to improve the productivity and performance of the technologies they use to produce items for DOD under procurement contracts. SBIR is DOD's participation in a legislatively-mandated program under which all major Federal agencies supporting R&D

must set aside a fixed portion of their research and development budgets for small firms; a program that is intended to take advantage of the fact that some small firms are highly innovative, and to enhance opportunities for small firms to participate in Government R&D programs.

Each of these programs involves quite different DOD management styles. Projects carried out under SBIR and ManTech are managed and administered at the program level within the Service, and in the Defense agencies in the case of SBIR. SCI is a DARPA initiative, which has as a major goal the transfer to the Services of SCI technologies embedded in hardware. This is intended to be accomplished primarily through close cooperation with the Services, in part, to help alleviate some of the hand-off problems DARPA has historically encountered. The management structure for the VHSIC program is innovative for DOD in that it is a DOD-wide cooperative effort managed in the Office of the Secretary of Defense, with explicit coordination among the Services.

### 1. THE VERY HIGH SPEED INTEGRATED CIRCUITS (VHSIC) PROGRAM

VHSIC is a multi-year, DOD-wide effort to develop, demonstrate, and, ultimately, field advanced integrated circuits (IC's) with capabilities and architectures at the leading edge of IC technology. From its inception, VHSIC was intended to be a development, rather than a basic research effort. For administrative purposes, VHSIC is a line item in the Air Force RDT&E budget, but it is a cooperative, tri-service effort managed in the OSD. Initially, VHSIC was funded under DOD budget category 6.2, but now it is funded under category 6.3.[36] Total funding for VHSIC may be on the order of $1 billion between 1980 and 1989.[37]

VHSIC chips are intended to meet quite specialized weapons-system requirements, particularly with respect to surviving in harsh military environments (for example, high or low temperatures and high radiation levels) and to providing very fast data-processing and signal-analysis capabilities. The VHSIC program is not just a research and development effort; rather, it includes application of VHSIC chips in operational weapons systems through a "technology insertion" initiative. Potential application areas identified by DOD include cruise missiles, military satellites, signal processing, command and control, wideband data communications, and "smart" weapons. Specific military systems applications are described for the three Services in the 1986 VHSIC Annual Report.[38]

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[36] Leo Young, DOD. Private communication, December 2, 1985.

[37] Funding estimates for VHSIC are given in: U.S. General Accounting Office. GAO Assessment of DOD's Very High Speed Integrated Circuits (VHSIC) Technology Program. GAO/NSIAD-85-37. May 8, 1985. p. 5. (Hereinafter referred to as GAO VHSIC May 1985.) A 1984 program "road map" prepared by DOD shows projected VHSIC funding totalling nearly $700 million, with budget figures for FY84, FY85, and FY86 projected at $125.1 million, $120.3 million, and $103.5 million, respectively. Actual DOD budget figures as of February 1985 show VHSIC budgeted at $120.1 million in FY84, $135 million in FY85, $193.8 million for FY86, and $158 million for FY87.

[38] Office of the Undersecretary of Defense for Acquisition, Very High Speed Integrated Circuits, Annual Report for 1986, 31 December 1986. (Hereinafter, 1986 VHSIC Annual Report), pp. 49–63.

The initial program formulation and planning activities began in 1978 in the Office of the USDRE.[39] DOD's motivation for VHSIC centered on two major concerns. The first, which had led to internal DOD discussions and reports circa 1977, was that the apparent U.S. lead over potential adversaries in IC technology had severely eroded.[40] In particular, the Soviet semiconductor industry had produced 16K random-access-memory (RAM) chips, albeit of inferior speed and quality compared to U.S. standards, only a few years after the introduction of 16K RAMs in the U.S.[41]

The second concern was that, as DOD's share of the total U.S. integrated circuit (IC) market declined, commercial manufacturers of IC's were concentrating on chip designs that had great commercial potential but that did not meet important military requirements, thus placing DOD at a technical disadvantage relative to commercial IC customers.[42] VHSIC was established as an industrial contract program to develop a new generation of IC's meeting DOD's requirements for speed, reliability, environmental hardness, etc., and to provide incentives for industry to establish a production capability to meet military needs and timelines on a par with industrial production capabilities for commercial chips.

The VHSIC Program Office is located in the Office of the USDRE; three Service Program Directors team with the Program Director to conduct periodic program reviews and to coordinate technical, financial and policy matters. A DOD-wide steering committee augments the management team. According to DOD, day-today technical and contract decisions are made by the Services. When VHSIC was established, this management structure was unique—prior R&D initiatives had been managed by an individual Service. Technical personnel in DOD,[43] as well as outside observers,[44] credit the cross-service management structure with benefits from improved inter-service technical communication. Also, in order to achieve scale economies, IC designs developed through the VHSIC program are intended for DOD-wide use, rather than being custom-designed for a particular military service.

VHSIC was announced in 1978 as a major R&D effort, and funding was authorized by Congress in 1979. However, the program was met with initial skepticism from critics who (i) doubted industry's willingness to make large investments in the relatively small military IC market, (ii) feared that the VHSIC program could permit one semiconductor manufacturer to dominate the marketplace and leave the military with a sole source for VHSIC chips, and (iii) were concerned that VHSIC guidelines requiring technology transfer would force contractors to reveal independently-developed proprietary information.[45] In May, 1979, the House zeroed the program's funding pending resolution of these concerns; funding was resumed in 1980 after the program was restructured and evidence of industry interest had become more apparent.[46]

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[39] Department of Defense. Office of the USDRE. The Very High Speed Integrated Circuits Program. Cleared for open publication April 19, 1984. p. 8. (Hereinafter referred to as DOD VHSIC April 1984.) See also, 1986 VHSIC Annual Report.

[40] DOD VHSIC April 1984. p. 8.

[41] A detailed five-part history of the early stages of VHSIC is provided by Martin, Jim. Very High Speed Integrated Circuits—Into the Second Generation. *Military Electronics/Countermeasures*, Dec. 1981 through April 1982. (Hereinafter referred to as Martin-[month], Year.) Martin-December, 1981, p. 52.

[42] Although DOD was a major early user of IC technology, starting with the Minuteman-II program in the early 1960's, by 1980 DOD's share of the total IC market had fallen to around seven percent, giving rise to DOD concerns that commercial requirements would dominate the semiconductor industry's products and processes. Also, the time lags involved between the introduction of new IC's in the commercial market and their use in operational military systems had increased from about two years in the early 1960's to eight to ten years by the 1980's. See, DOD VHSIC April 1984. p. 4-5.

[43] DOD, VHSIC Program Office, private communication, January 1986.

[44] William G. Ouichi discusses VHSIC's management structure and the relationships between DOD and the VHSIC contractors in Chapter 6 of The M-Form Society. Reading, MA: Addison-Wesley. pp. 124-142, 1984.

The original VHSIC program consisted of four, overlapping phases. Phase 0 (planning and concept formulation), Phase I (pilot production lines for silicon chips with 1.25-micron features and brassboard circuits incorporating these), Phase II (pilot production lines and brassboards using silicon chips with 0.5-micron features), and Phase III (problem-solving technical efforts in support of Phases I and II). The scope of the program was later expanded, by augmenting Phase III and adding Technology Insertion and Yield Enhancement efforts.[47]

In 1980, the VHSIC Program Office was established, and $10.3 million of Phase 0 contracts were awarded to a total of nine industry teams.[48] In 1981, Phase I prime contractor awards totalling almost $168 million were made to six contractors.[49] Phase II begin in FY84 and is expected to last through FY88. The Phase II goal is development of faster, submicron-technology chips with built-in test capability at the chip level. The prime contractors selected for Phase II are IBM, Honeywell, and TRW.[50]

According to Julian, two Phase 0 contractors (GE and Raytheon) that were not selected for Phase I awards have launched their own VHSIC-like programs.[51] The Phase I contractors are believed to have invested some $300 million of their own funds in VHSIC-related activities, and Phase II contractors are expected to make large investments as well.[52]

Phase III work provides technical support to the main program through shorter, limited-scope efforts focusing on key technical areas such as fabrication processes, computer-aided design (CAD) tools, fault-tolerant architectures, chip-level test techniques, and reliability assurance.[53] Phase III VHSIC efforts were begun in FY80, and were largely completed by FY85.

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[45] See Martin-December, 1981, pp. 58, 71–73, and Ouichi, pp. 133–135 for discussions of the early controversies concerning VHSIC.

[46] Martin-December, 1981, p. 71; DOD VHSIC April 1984: p. 9.

[47] When VHSIC was initiated, commercial IC chips incorporated minimum feature sizes of two to three microns. When the program was being planned, according to published sources, VHSIC excluded gallium arsenide technologies in order not to overlap with DARPA R&D efforts in these areas (see, for example, Martin-December, 1981, p. 58).

[48] DOD VHSIC April 1984. p. 8.

[49] DOD VHSIC April 1984. p. 8; Martin-January 1982. p. 60. The Phase I prime contractors were TRW, Westinghouse, Texas Instruments, IBM, Honeywell, and Hughes. (Hughes received two contracts.) TRW, Westinghouse, and Hughes headed multi-contractor teams working on Phase I.

[50] For an industry perspective on VHSIC, see: Julian, Ken. Defense Program Pushes Microchip Frontiers. High Technology. May 1985: p. 49–57; and Lyman, Jerry. How DOD's VHSIC Is Spreading. Electronics. Dec. 16, 1985.

[51] Recently, GE announced that it had developed a proprietary family of VHSIC-like chips for aerospace and defense applications using its own funding. GE will not be required to sell its designs to potential competitors, as DOD VHSIC contractors must. See, Philip J. Klass, GE Produces Family of VHSIC-Like Operational Chips for Aerospace, Aviation Week and Space Technology, January 26, 1987: pp. 88–89.

[52] Julian, op. cit., p. 57.

Although VHSIC is funded by DOD as a 6.3 program, the nature of the work done varies. For example, even though VHSIC is not a "research for research's sake" program, in that the work is targeted to meet specific goals, Phase III work is similar to the type of work typically funded under budget categories 6.1 and 6.2. The Technology Insertion efforts, which seek to demonstrate VHSIC applications in new military systems, are similar in nature to work done under budget category 6.4.[54]

According to a recent GAO report on VHSIC,[55] the program was expected to cost a total of some $339 million, with $178 million allocated to "first-generation" (Phase I) technology. The six Phase I contractors received contracts to develop 1.25-micron chip technology, to test and fabricate several types of chips, and to demonstrate applications of these in prototype, or "brassboard", assemblies constructed for engineering applications. Although technical progress was reported by DOD, the GAO assessment, which was conducted in 1983–84, found that all six contractors encountered difficulties in design and production of the VHSIC chips. Also, according to GAO, it became apparent early in the program that cost and schedule overruns were likely.[56]

In 1982, DOD expanded the VHSIC program objectives. Phase III was expanded to include additional work on materials and submicron-level definition and design software. The expanded program included a Yield Enhancement and manufacturing technology initiative involving subsidies intended to improve the six Phase I contractors' manufacturing efficiencies: $102 million starting in FY84 to enhance the contractors' pilot production lines, and $90 million starting in FY85 for improved manufacturing technologies related to chip production, assembly, and test.[57] The expanded program also included a technology insertion initiative to increase the near-term demand for VHSIC technology by providing subsidies to contractors and to defense system developers within the military departments. These subsidies are intended to offset the relatively higher costs of designing, building, and evaluating VHSIC prototypes, compared with conventional IC technology. The GAO reported that DOD has committed an additional $148 million for 38 potential system applications of VHSIC technology, and that DOD plans to provide some $62 million more for additional applications.[58] In addition to the above, increased funding for Phase I and Phase II technologies and CAD (Computer Aided Design) amounted to some $102 million.[59]

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[53] See Martin-December, 1981 p. 72 for a description of Phase III research areas. Phase III contracts include small businesses and universities, as well as large semiconductor and electronics firms; over 60 Phase III contracts were awarded. Selection of Phase III performers was based mainly on the technical capabilities of the performers and other technical needs of the program; some $5–6 million has gone to universities.

[54] DOD VHSIC Program Office, Private communication, January 1986.

[55] GAO VHSIC May 1985 p. 2, 5.

[56] GAO VHSIC May 1985 p. 2–3.

[57] See GAO VHSIC May 1985 p. 2–4.

[58] Ibid., p. 4.

[59] Ibid., p. 2, 5.

Thus, despite DOD's expectations that the VHSIC program would cost some $339 million when the first funding profile was developed in May 1981, as of February 1984, the funding profile totalled nearly $781 million, with about $350 million obligated through FY84.[60] Most of the additional cost is attributable to the expanded scope of the program. Actual total program costs may be higher still, based on funding requirements of some $1.02 billion proposed by the VHSIC program director in February 1984.[61] The final FY1987 appropriation in the Air Force RDT&E budget for VHSIC is $131 million.[62] DOD has asked for budget authority for VHSIC of $101 million for FY88 and $58 million for FY89.[63]

Following up on the VHSIC Program, DOD has established under the same management a new program known as MIMIC, which stands for Microwave, Millimeter-wave, Monolithic Integrated Circuits program. MIMIC is intended to do for gallium arsenide-based semiconductor chips what was done under VHSIC for silicon-based devices.[64] Such chips would have different purposes than the computational capabilities of VHSIC chips; for example, the MMICs are expected to serve as sensing elements in advanced radars and microwave communications systems.[65] MIMIC has received FY87 funding of $10 million, and DOD has asked for $49 million in FY88 and $86 million in FY89.[66]

### 2. THE STRATEGIC COMPUTING INITIATIVE

The Strategic Computing Initiative (SCI) was started at DARPA in November 1983 with four major goals: (i) to advance machine intelligence technology across a broad front in order to assure a continued U.S. lead through the next decade in advanced computer technologies and artificial intelligence (AI); (ii) to transfer machine intelligence technology resulting from university research previously and currently sponsored by DARPA to the military services and to the defense industry; (iii) to increase the availability of AI-trained scientists and engineers in unversities by increasing sponsored graduate student research in AI; and (iv) to provide a broad base (infrastructure) of supporting research for advanced machine intelligence technology.[67]

SCI may be more recognizable in terms of its principal Military Applications projects, which include: the Autonomous Land Vehicle, systems for Naval Fleet Command Center Battle Management, systems for Army AirLand Battle Management, the Pilot's Associate, and a system for Radar/Optical Imagery Analysis.[68] According to DOD, the role of the applications projects is,

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[60] Ibid., p. 5.

[61] Ibid.

[62] Defense Daily, October 26, 1986.

[63] Defense Daily, January 9, 1987.

[64] Michael Kachmar, DOD Gets Serious About GaAs MMICs, Microwaves and RF, November 1985, p. 35.

[65] Larry Waller, The Race is on to Develop Microwave GaAs ICs for DOD, Electronics, October 30, 1986, p. 29.

[66] Defense Daily, January 12, 1987.

[67] Strategic Computing First Annual Report. DARPA. Feb. 1985. See also, Strategic Computing Second Annual Report, February 1986. (Hereinafter, SCI First [Second] Annual Report.)

[68] SCI Second Annual Report, p. 3.

> . . . to provide a realistic task environment for technology research. Also, these projects are designed to serve as the principal means of demonstrating the emerging technology and of transferring it to military systems and to the industrial base.[69]

Although a fraction of SCI funding was originally in DOD budget category 6.1, it has now all been transferred into budget category 6.2.[70] Appropriations for SCI were $50 million in FY84, and $72 million was included in the FY85 continuing appropriation.[71] For FY86, DARPA requested $142 million for SCI (compared with a $46.2 million request by the NSF for Advanced Scientific Computing), but actual funds budgeted for SCI in 1986 totaled $116 million, and in FY87, $104 million.[72] Projected funding over the first five years of SCI was about $600 million, which represents a substantial share of all Federal funding, if not all funding from all sources, for advanced computer science research. Thus, SCI is expected to have a substantial impact on the pace and direction of developments in advanced computing in the U.S.

Although DARPA's mission is to develop advanced technologies for military use, SCI research could yield dual-use technologies that might be useful in the commercial computer market.[73] Part of the policy debate concerning SCI addresses the feasibility of achieving the large advances in AI that would be necessary to meet DARPA's stated goals. Some of the debate also questions the desirability of increased reliance on AI in battle (e.g. for SDI). Still another set of issues concerns the increased role of the military in U.S. advanced computer and AI research.[74]

The FY86 budget for SCI of $63.2 million was allocated among research performers as follows: 41 percent to universities, 48 percent to industry, seven percent to DOD laboratories, and five percent to an FFRDC. Major research areas were multiprocessor system architectures (29.5 percent of funding), applications (22.7 percent), generic AI systems (20.5 percent), infrastructure (20.0 percent), and microelectronics (7.3 percent).[75] In its 1984 report, DARPA projected that the number of graduate students supported by SCI would increase from approximately 100 in 1984 to around 500 in 1986, and that the numbers of scientists and engineers supported by SCI in universities, industry, and DOD would more than double between 1984 and 1986.[76]

According to DARPA, about half the FY84 SCI funds were allocated through competitive procurement actions using Requests for Proposals (RFP's). University involvement in SCI competitive procurements has principally been through joint industry-university proposals.[77]

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[69] Ibid.

[70] DOD. Leo Young. Private communication, November 1985.

[71] DOD reports an FY86 budget for SCI of $63.2 million in the SCI Second Annual Report, p. 26.

[72] Congressional Research Service, Issue Brief 85105, Supercomputers and Artificial Inteligence: Federal Initiatives, by Nancy R. Miller, updated February 26, 1987.

[73] Dwight B. Davis, Assessing the Strategic Computing Initiative, High Technology. April 1985. pp. 41-49.

[74] For a discussion of the policy debates concerning SCI and other Federal computing initiatives, see Congressional Research Service, op. cit.

[75] DARPA. SCI Second Annual Report. February 1986.

[76] SCI First Annual Report, op. cit. The Second Annual Report did not comment on numbers of students or other researchers supported by SCI.

### 3. THE DOD MANUFACTURING TECHNOLOGY PROGRAM (MANTECH)

DOD's Manufacturing Technology Program (ManTech) has the overall goals of (i) improving the manufacturing productivity and responsiveness of the defense industrial base, and (ii) significantly reducing defense system acquisition and life-cycle costs.[78] ManTech seeks to accomplish these goals through initiatives intended to bridge the gap between innovations in production technology and their full-scale application on the factory floor. It provides "seed money" for initial demonstrations of new or improved technologies, including computer technology, in the production of defense systems and materiel. Contractors are expected to adopt these technologies in producing defense systems at a lower cost.

The GAO has reviewed the ManTech Program, with an emphasis on the program's management and administration, particularly DOD's project selection and evaluation methods.[79] This section draws heavily on the GAO report.

Another recent study of the ManTech program was carried out by the Manufacturing Studies Board of the National Academy of Sciences and National Academy of Engineering with funding from the National Science Foundation and with the cooperation of the Services.[80,81] Of special interest is Appendix B of this report, which contains a short history of the ManTech program and of some of the policy issues that ManTech has aroused.

According to the GAO report, DOD regards the ManTech Program as important because of its potential to achieve DOD's productivity and cost reduction goals. Investments funded by ManTech are intended to reduce private contractors' costs and risks in implementing new or more efficient manufacturing techniques, processes, and equipment; thereby speeding technology transfer and encouraging the implementation of new manufacturing technologies. Without ManTech funding, DOD believes that private contractors may find it too risky to make large investments in new manufacturing technologies in the time frame necessary to meet DOD's mission requirements.[82]

Efforts to improve productivity in modern manufacturing have existed in DOD for several decades: the Air Force began a program in the 1950s to improve the aerospace industry's manufacturing techniques;[83] the Army began a similar program in 1964 emphasizing the manufacture of ammunition; and the Navy formally established a manufacturing technology program in FY77 after performing related work since the late 1960s.[84]

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[77] SCI First Annual Report, p. 8.

[78] An outline of ManTech objectives and evaluation criteria is given in Statement of Principles for Department of Defense Manufacturing Technology Program. DOD. Washington, D.C., March 14, 1980.

[79] U.S. General Accounting Office. DOD Manufacturing Technology Program: Management Is Improving But Benefits Hard to Measure (GAO/NSIAD-85-5) and Supplement (GAO/NSIAD-85-5a). November 30, 1985.

[80] Manufacturing Studies Board, The Role of the Department of Defense in Supporting Manufacturing Technology Development, National Academy Press, Washington, D.C., 1986.

[81] The Manufacturing Studies Board of the National Research Council is expected to release a new report in May 1987 on the management and organization of the ManTech programs which was sponsored and paid for by DOD. It will offer recommendations for improvements in the program. Source: Janice Greene, MSB, private communication, March 20, 1987.

[82] Ibid., p. 2-3, 31.

The military services each manage their own ManTech programs through central program offices and engineering support staff, and the OSD has a small staff for general oversight and policy guidance. The Manufacturing Technology Advisory Group, composed of government and industry officials, coordinates and promotes the ManTech Program.[85] The services vary in the composition of their ManTech programs; Air Force and Navy projects are mainly performed by defense contractors, while a substantial portion of Army projects is performed in DOD-owned plants, laboratories, and arsenals.

Up until the early 1980's, ManTech funding was mainly included in the services' procurement accounts, although some ManTech projects were funded in RDT&E or Operations and Maintenance accounts. In recent years, the Congress has deliberated whether ManTech should be budgeted in RDT&E accounts, and, as a result, Army ManTech was put in the RDT&E account for FY83. As of FY84, most of the three Services' ManTech expenditures were charged to RDT&E rather than to procurement.[86]

The GAO reported that ManTech funding was growing rapidly—program funding was about $131 million in FY83 and $200 million (cut from a requested $232 million) in FY84. According to the GAO report, total ManTech funding was about $660 million for FY73 through FY79 and $830 million for FY80 through FY84.[87] The ManTech budgets for FY85, 86, and 87 were $189, $198, and $124 million, respectively. DOD has asked Congress for $165 and $169 million for FYs 88 and 89.[88]

ManTech funds go primarily to defense contractors and to some DOD facilities, such as the Naval Air Rework Facility in San Diego and the Watervliet Arsenal in New York State, for initial demonstrations "on the factory floor" of technically feasible manufacturing improvements in such diverse areas as fabrication of materials and composites, robotics, process and production engineering, inspection and quality control, electronics, and fault indentification and isolation.[89] DOD evaluates ManTech project proposals based on their expected return on investment (considering both cost savings and quality improvement), taking into account the project's technical and economic feasibility and timeliness with respect to DOD production timeliness.

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[83] For a discussion of the Air Force's role in developing numerical control and computer-aided manufacturing methods and their impacts on U.S. manufacturing technologies, see David F. Noble's chapter "Command Performance: A Perspective on the Social and Economic Consequence of the Military Enterprise" in Military Enterprise and Technological Change. Merritt Roe Smith, Ed. The MIT Press, Cambridge MA. 1985. p. 340–346.

[84] GAO/NSIAD-85-5 p. 1.

[85] Ibid., p. 2.

[86] Ibid.

[87] Ibid.

[88] Lloyd Lehn, DOD Office of Industrial Resources, private communication, March 31, 1987.

[89] See GAO-NSIAD-85-5A for a description of 132 selected projects and outcomes that GAO studied in its review of the ManTech program. This study examined a wide range of technologies for each service, with a typical project duration of two to four years. Significant benefits were reported for some of the projects, but not all projects reported benefits and some were never implemented in production.

A project can span several years: five to six years is typical, according to GAO, but some projects take as long as ten years from planning and project demonstration to full implementation. A substantial portion of the projects is never implemented in production, either because of the lack of technical success and/or economic feasibility for production use, or because production requirements change after the project is initiated.

The GAO had previously reviewed the ManTech Program, noting that it could significantly reduce defense acquisition costs but recommending that better criteria be used to rank and select projects, that improved management information systems be adopted, and that internal program evaluations and better planning for technology implementation be adopted. In addition, GAO had earlier recommended that the costs and benefits of ManTech projects be tracked.[90]

In its 1985 report, GAO noted that the House Appropriations Committee Surveys and Investigations Staff had recommended improvements in program management in March 1980; in addition, the GAO noted that between 1980 and 1985 there were five internal DOD reviews and audits of the program.

The objectives of the 1985 GAO study were to evaluate the overall effectiveness of ManTech and to evaluate changes in program management since the 1979 report. The GAO study found that, although both DOD and defense contractor personnel stated that ManTech provided useful results, there was no consensus (even among the Services) on criteria with which to evaluate its effectiveness. Also, GAO found no uniform, DOD-wide system for collecting project results, although DOD was in the process of establishing a tri-service data base during 1984. Potential measures with which to evaluate the effectiveness of ManTech projects were complicated by the duration of ManTech projects and by lags in the DOD acquisition cycle, during which manufacturing and/or system requirements often change.[91] Noting that both passive and active channels of technology transfer and diffusion were established by the services, the GAO found that the lack of a management structure facilitating systematic data collection and dissemination made benefits from technology transfer and diffusion hard to identify.[92]

An examination of the 132 cases studied in the 1985 GAO review [93] shows a broad range of activities, ranging in level of general applicability from the relatively generic (e.g., "Gallium arsenide substrate fabrication", funded by the Navy at a level of $501,000, with cost savings reported and potential applications to several military systems and at several contractor sites) to the quite specific (e.g., "Improvement of honing equipment and procedures" for 105MM M68 tubes, funded by the Army at the Watervliet Arsenal for $178,000 with a reduction in tube honing times reported, but with no other uses for the technology identified).

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[90] U.S. General Accounting Office. Manufacturing Technology—A Changing Challenge to Improved Productivity. (GAO/LCD-75-436) June 1976; U.S. General Accounting Office. Manufacturing Technology—A Cost Reduction Tool at the Department of Defense That Needs Sharpening. (GAO/PSAD-79-99) Sept. 11, 1979.

[91] See GAO/NSAID-85-5 for a discussion of GAO's findings and recommendations.

[92] Ibid. p. 9. Examples of technology transfer mechanisms noted by GAO are routinely-published technical reports on ManTech projects, regular meetings of the Manufacturing Technology Advisory Group, and end-of-project technology demonstrations held for DOD and contractor personnel.

[93] GAO/NSIAD-85-5A.

ManTech priorities and project selection criteria most likely require making tradeoffs between seeking (i) identifiable, immediate benefits from improvements in a specific production step for a specific military system that can be achieved at relatively modest cost, and (ii) potentially larger (but more difficult to identify in the short term) aggregate benefits achieved from developing improved production techniques that might be useful at several sites and systems, but might only be achieved at higher cost. If costs are borne by one Service, but potential benefits are likely to be realized by other Services, different projects are likely to be selected than if ManTech were funded on a DOD-wide basis.

Closely related to ManTech is the Industrial Modernization Incentive Program, or IMIP.[94] IMIP is concerned to provide incentives for defense contractors to invest in state-of-the-art equipment in order to reduce the costs of producing or improve the quality of products purchased under negotiated contracts. Begun in the Air Force as the Technology Modernization Program, IMIP allows contractors to retain a portion of the cost savings arising from productivity enhancing investments, thus creating an immediate incentive for such improvements.

### 4. THE SMALL BUSINESS INNOVATION RESEARCH PROGRAM IN DOD

The Small Business Innovation Research (SBIR) Program was authorized by P.L. 97-219, the Small Business Innovation Development Act of 1982, enacted July 22, 1982.[95] Effective in FY83, the Act amended the Small Business Act (15 USC 638) in order to give small businesses a greater share of Federal research and development contract awards.[96] The purposes stated in P.L. 97-219 include stimulating technological innovation, using small businesses to meet Federal R&D needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing private sector commercialization of innovations derived from Federal R&D.[97]

#### *a. Overview of SBIR*

According to P.L. 97-219, after FY82 each Federal executive agency having an extramural R&D budget exceeding $100 million in a fiscal year is required to establish an SBIR program.[98] As defined in P.L. 97-219, an SBIR program reserves a portion of a Federal agency's extramural research or R&D effort for awards to small businesses.[99] Each agency is required to establish a uniform, three-phase process for its SBIR program. Phase-I awards are made to small businesses in order to determine the scientific and technical merit and feasibility of ideas they submitted in response to SBIR program solicitations. Firms that successfully complete Phase-I projects are eligible for Phase-II awards, which are based on the results from the Phase-I effort and on the scientific and technical merit of the Phase-II proposal. Phase II is the principal SBIR research or R&D effort, in which the ideas proposed in Phase I are developed in order to meet the mission agency's technical need. If two or more Phase-II proposals are evaluated as being of approximately equal scientific and technological merit and feasibility, preference will be given to proposals demonstrating Phase III, non-Federal capital commitments. Under Phase III, the small business is expected to use non-Federal funds to pursue commercial applications of its Phase-II work. However, non-SBIR Federal funds can be used to fund Phase-III activity if the Federal agency would be the customer for the new technology.[100]

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[94] David M. Kennedy, Making Manufacturing Modern, Military Logistics Forum, June 1985: 38-44. See also, Manufacturing Studies Board, 1986, op cit.

[95] P.L. 97-219 was amended by P.L. 99-443, enacted September, 18, 1986, which reauthorized the Act through fiscal year 1993.

[96] A "small business" is one which has 500 or fewer employees. Only small businesses operated for profit and based in the U.S. are eligible to participate in SBIR. "Minority-" or "woman-owned" small businesses are those that are at least 51-percent owned by minority or female individuals who also operate them. [U.S. Small Business Administration. Office of Innovation, Research, and Technology. Pre-Solicitation Announcement: Small Business Innovation. SBIR/PSA-FY85. March 1985. (Hereinafter referred to as: SBA March 1985.)]

[97] P.L. 97-219 Section (2)(b). See, Congressional Research Service Issue Brief 86118, Small Business Innovation Development Act: H.R. 4260 Amendments to P.L. 97-219, by Wendy H. Schacht, archived Feb. 2, 1987.

[98] P.L. 97-219 Section (4)(f).

Small business firms retain the patent rights to inventions developed with Government support under SBIR, although the Government reserves the right to a royalty-free license for its own use. Rights to technical data and software developed under SBIR awards also remain with small business contractors; the Government has royalty-free use of the data, whether or not it results in a patent. For the first two years after the project is completed, the Government has limited rights to use, but not to disclosure, of resulting data.[101]

Agencies that meet the $100-million threshold requirement must set aside a percentage of their extramural research or R&D budget for SBIR; the percentage required to be set aside is determined by section (4)(f) of P.L. 97-219, which establishes a graduated phasing-in of the program to a steady-state level of 1.25 percent starting in FY87 (or after the third year in which an agency, other than those required to have an SBIR program in FY83, is required to establish one).

Each agency identifies problems or research areas applicable to its mission requirements and issues small business research solicitations cooperatively with the Small Business Administration (SBA). The agency evaluates Phase-I proposals received in response to its solicitation, selects awardees for SBIR funding, and administers its SBIR funding agreements. Each agency is required to make an annual report on its SBIR program to the SBA and to the Office of Science and Technology Policy.[102] P.L. 97-219 also mandates an annual report to the Congress on the SBIR programs of the Federal agencies and on the Administration's SBIR information and monitoring activities.[103] As of 1985, twelve Federal departments and agencies, including DOD, were required to have SBIR programs.[104]

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[99] P.L. 97-219 Sections (4)(e)(4) and (4)(e)(5).

[100] U.S. Department of Defense. Defense SBIR Program Solicitation Number 86.1. October 1, 1985. p. 2-3. (Hereinafter referred to as DOD SBIR PSN86.)

[101] Ibid., p. 9-10.

[102] P.L. 97-219 section (4)(g).

[103] P.L. 97-219 section (3)(7).

[104] SBA March 1985. p. 6.

In FY83, the first year of the SBIR program, a total of 8,814 SBIR proposals was received by the affected agencies, and approximately $44.5 million was awarded to small businesses. During FY84, nearly 8,000 proposals were received, and approximately $48 million was awarded. About a third of these proposals were submitted to DOD, which accounted for almost half the dollars awarded in FY83 and over 90 percent in FY84.[105] The SBA has estimated that the amount awarded under SBIR may increase to nearly $500 million once the program is fully implemented in FY87.[106]

### *b. The SBIR Program in DOD*

In FY 1982, DOD voluntarily instituted a precursor of SBIR, the Defense Small Business Advanced Technology Program (DESAT). DOD received 1,103 DESAT proposals in FY 1982 and made 100 contract awards of approximately $50,000 each. Of these 100 awards, 33 Phase-II awards were made in FY83, totalling $4.7 million.[107] DESAT will be phased out with the completion of the Phase-II DESAT contracts.[108]

The DOD SBIR Program Solicitation for 1986 states that three categories of RDT&E come under "research or R&D" in the SBIR Act: Basic Research (6.1), Exploratory Development (6.2), and Advanced Development or Engineering Development (6.3 or 6.4).[109] In practice, DOD has appeared to calculate the required set-aside based on the extramural portion of the "R&D" budget categories 6.1 through 6.5 only, a practice recently codified in law.[110] Data on the overall size of the DOD SBIR program are shown in Table XV.

TABLE XV.—MAGNITUDE OF DOD SBIR PROGRAM

| | Fiscal year— | | | | | |
|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Statutory percentage | 0.1 | 0.3 | 0.5 | 1.0 | 1.25 | 1.25 |
| Estimated Awards (millions) | $16.7 | $43 | $79 | $160 | $204 | $262 |
| Actual Awards (Millions) | $20.6 | $44.6 | NA | | | |

Source: DOD SBIR Fact Sheet, p. 1.

Each of the five original DOD SBIR components (Army, Navy, Air Force, DARPA, and Defense Nuclear Agency (DNA)) selects R&D topics related to its mission requirements and submits these topics to the Office of the Secretary of Defense for inclusion in the DOD SBIR solicitation. The SBA publishes a pre-solicitation brochure listing the topics about a month before the formal DOD solicitation is issued.[111] Each year, DOD publishes a formal solicitation document with detailed topic or problem descriptions and procedures for submitting Phase-I proposals.[112] Starting with FY86, the SBIR solicitation also contains topics from the Strategic Defense Initiative Organization (SDIO). After the solicitation closing date (typically the January 31 prior to the start of the next fiscal year), each DOD SBIR component is responsible for evaluating its own proposals, awarding contracts from available funds, tracking the SBIR work done, and reporting the results from that work.[113] Table XVI shows data on the numbers of proposals and awards for each of the participating DOD units.

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[105] Calculated from data given in SBA March 1985, page 2 and U.S. Department of Defense. Defense SBIR Program. Abstracts of Phase I Awards 1984. April 1985. p. ii. (Hereinafter referred to as DOD SBIR Abstracts 1984.)

[106] SBA March 1985. p. 2.

[107] DOD SBIR Abstracts 1983. April 6, 1984. p. ii.

[108] SBIR awards made in FY 1983 and counted towards the SBIR mandate include the 33 Phase-II DESAT awards, along with 283 Phase-I SBIR awards, for a total of $20.6 million. (DOD SBIR Fact Sheet, 4/24/85, p. 2)

[109] DOD SBIR PSN86, p. 4.

[110] DOD. Leo Young, private communication, November 1985. Section 1 of P.L. 99-443 declares that funds for DOD "operational systems development" (so-called 6.6 accounts) are not subject to the SBIR set-aside requirements.

TABLE XVI.—DOD SBIR PROPOSALS AND AWARDS

[Numbers of items]

| | Topics | Proposals received | Phase I awards [3] | Phase II awards |
|---|---|---|---|---|
| Fiscal year 1983 Phase-I Proposals: | | | | |
| Army | 182 | 1,246 | 96 | 20 |
| Navy | 131 | 944 | 67 | 40 |
| Air Force | 75 | 496 | 100 | 50 |
| DARPA | 8 | 128 | 12 | 8 |
| DNA | 10 | 88 | 8 | 2 |
| Total | 406 | 2,902 | 283 | 120 |
| Fiscal year 1984 Phase-I Proposals: | | | | |
| Army | 111 | 758 | 81 | |
| Navy | 147 | 861 | 99 | |
| Air Force | 283 | 1,208 | 163 | |
| DARPA | 17 | 107 | 15 | |
| DNA | 8 | 80 | 12 | |
| Total | 566 | 3,014 | 370 | |
| Fiscal year 1985 Phase I Proposals: | | | | |
| Army | 111 | 803 | 117 | |
| Navy | 138 | 851 | [2] 58 | |
| Air Force | 218 | 1,272 | 231 | |
| DARPA | 17 | 130 | 14 | |
| DNA | 7 | 90 | 18 | |
| SDIO [1] | 18 | 414 | [2] 0 | |
| Total | 509 | 3,570 | 438 | |

[1] Supplemental solicitation 1/1/85.
[2] As of August 1985.
[3] For FY85, refers to proposals selected for negotiation.

Source: DOD SBIR PSN86 p. 3.

DOD Phase-I awards typically consist of one-half to one person-year of effort over a period not to exceed six months, subject to negotiation. Technical reviewers base their conclusions only on the information contained in the proposal, taking into account the quality and relevance of the work, the qualifications of the principal investigator, anticipated benefits to the total DOD R&D effort, adequacy of the proposed work to demonstrate feasibility of the concept, and cost to the Government. Phase-II awards typically consist of two to five person-years of effort over a two-year period, subject to negotiation. For Phase II, the technical evaluation also takes into account the degree to which Phase-I objectives were met and the adequacy of Phase-II objectives to satisfy the technical problem or need. Phase III is intended to use non-Federal funds for commercialization, but DOD may award follow-on contracts from non-SBIR funds.[114]

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[111] See, for example, SBA March 1985, pp. 17-20. This description of DOD's implementation of SBIR is summarized from the "DOD SBIR Fact Sheet" dated April 24, 1985 and issued by the Office of the Secretary of Defense (Small Business and Economic Utilization Policy).

[112] See, for example, DOD SBIR PSN 86.1.

[113] DOD SBIR Fact Sheet, p. 2.

#### *c. Projects Funded Under DOD SBIR*

The DOD SBIR program solicitation lists research topics for each of the components, and provides a brief description, usually a few paragraphs, of each research area or problem. The solicitation lists the contact points for proposal submissions, and also explains the kinds of technical assistance available to small businesses in support of SBIR work.[115]

DOD reports that many of the 3,000 small business requestors that responded to the FY84 and FY85 SBIR program solicitations believe that the information provided by DTIC enabled them to make better-informed decisions about whether to submit a proposal, as well as to offer stronger proposals.[116] Three out of four firms that submitted winning proposals in FY84 were assisted by DTIC during the solitation period; during this period DTIC assisted more than 2,000 small businesses.[117]

The FY86 SBIR proposal solicitation was distributed on October 1, 1985, and the due date for proposals was January 1, 1986. Subject areas included in the FY86 solicitation include the physical sciencies, engineering, computer science and artificial intelligence, and such social science areas as training and human factors research.

## G. Issues Concerning DOD Sponsorship of R&D in Industry

### 1. OVERVIEW

This chapter has been largely confined to a descriptive and historical overview of the performance of DOD-sponsored RDT&E in industry, with an emphasis on those activities that lie closer to the basic and applied research end of the spectrum. Little or no attention has been paid to the main body of DOD support of R&D in industry: the development of major weapons and weapons delivery systems, communications and control systems, components, and so on.

In view of this focus and limitation, it would be inappropriate to dwell upon many of the central policy issues concerning DOD industrial RDT&E. However, a few of those issues are raised here to indicate some of the kinds of concerns that are raised. In addition, some of the issues having to do with the relationship of DOD industrial R&D to civilian technology development are also raised. Other chapters in this report discuss still other issues in such areas as human resources, Federal technology transfer to industry, and the impact of DOD R&D support on the universities.

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[114] Ibid.

[115] The Defense Technical Information Center (DTIC) will provide (i) bibliographies of technical reports resulting from previous DOD-funded R&D, (ii) copies of the reports cited in these bibliographies, (iii) information about DOD-sponsored work currently in progress in SBR proposal areas, (iv) referrals to DOD-sponsored Information Analysis Centers for informational or consulting services, and (v) references to other sources of scientific and technical information needed to prepare SBIR proposals to DOD. See DOD SBIR PSN86 pp. 11-13 and 281-287.

[116] DOD SBIR PSN86, p. 12-13.

[117] DOD SBIR Fact Sheet, p. 4-5. DOD automatically mails its program solitications to small businesses that have asked to be placed on SBA's SBIR mailing list (21,000 firms for FY85). For FY85, an additional 5,500 firms requested the SBIR solicitation directly from DOD.

### 2. SELECTED ISSUES FOR CONGRESSIONAL CONSIDERATION

- Does the current organization, management, and budget priorities associated with DOD support of industrial R&D yield the most appropriate range of new and more effective defense technologies?

Today, the majority of DOD's RDT&E work is performed by industrial firms in the private sector under contract. This is not the only way the defense R&D activity might be performed. For example, a greater fraction of the work could be done by in-house agency researchers, working in laboratories and at the various arsenals and facilities devoted to new technology. Yet another alternative would be for DOD to depend more heavily on the private sector for new technology developments, and to pay for the cost of such developments indirectly through the profit margins allowed on procurements from industry. It is not clear that either of these extremes, or other approaches would be superior to the current system, but it may be worthwhile to ask whether a "rebalancing" of the responsibilities in the system might be in order.

- Are today's new defense technologies too sophisticated and technologically complex, or is such sophistication and complexity essential to America's national security?

It is a cornerstone of current U.S. defense policy that our survival depends critically on possessing and using defense technologies whose performance is superior to those of our potential adversaries. The argument is that we are unable or unwilling to base our strength on the sheer size of our defense effort and that superior technology is our trump card.

However, questions have also been raised about whether the systems now being developed and put into operation are so complex and sophisticated that they have become unreliable and difficult to operate, and that they may be impossible to repair under battlefield conditions. Some of them incorporate so many simultaneous advances in the state of the art of technology, that the chances that a new concept will actually perform as initially expected may be very small, while the chances that it will cost more than initially estimated may be very large. Furthermore, some argue that these highly sophisticated new systems are insufficiently resilient to be able to adapt to the inevitable uncertainties and contingencies in a war-fighting environment, both natural and man-made.

Part of this debate may turn on the semantics of what is meant by superior technology. All too frequently, superior is taken to be synonymous with advanced, when, in fact, more prosaic technologies may be better suited to the task at hand. There may be little room for prosaic technologies in a system that is driven at the outset by advances in the state of the art of such fields as physics, electronics, and supercomputing.

Again, this is not to suggest that the arguments of any side of this discussion hold the clear high ground, but only that the debate is worth having.

- Does DOD pay too high a price for marginal increments in performance of specific items of defense technology, or might more "defense" be purchasable by focusing the same funds on larger numbers of marginally less-advanced systems?

This issue is a corollary of the previous one. Current defense policy includes paying substantially greater prices for weapons systems that have marginally higher performance than second best alternatives, often with substantial decreases in reliability and availability. Would the overall fighting capability be greater, at the same total cost, with a larger number of less expensive, more reliable weapons?

- Does the current process for defense technology development carry with it an inevitable commitment to procurement of resulting systems?

Some observers have argued recently that defense RDT&E leads through a nearly inexorable process to downstream procurement expenses, even going so far as to assert that a dollar of defense R&D "generates" X dollars of future procurement. If true, this suggests that DOD does not have an adequate process for judging new opportunities and for terminating projects at intermediate stages of development. By analogy, students of industrial innovation have often noted that one of the weakest links in firms' R&D management can be the absence of a good process of project termination. Congress may wish to examine whether DOD should strengthen the capability of its R&D decisionmaking process to terminate unpromising programs at earlier stages of development, in order to focus scarce R&D resources on more promising ones.

- Are RDT&E funds spent wisely and efficiently by DOD and by its industrial contractors?

This generic issue can never be answered fully or satisfactorily, since the counterfactual world in R&D management is inevitably hypothetical. Since intuition and judgment must play a large role in evaluating R&D programs, the door will remain open to continuing discussion of this issue. The issue subsumes a number of important subissues, such as the openness of DOD RDT&E contracting procedures to new entrants and new concepts, the balance of fundamental research versus systems development, the effectiveness of DOD oversight of contractor efforts, the ways in which procurement procedures enhance or detract from incentives for contractor performance, and so on.

- How might existing procurement and contracting incentives be modified to enhance the entry of new firms into the defense arena, to stimulate cost cutting, and to strengthen the performance of defense technologies?

At least since the early 1960s, DOD has experimented with new ways of creating incentives for defense contractors to cut costs and enhance performance. Most of these have involved establishing some features of a competitive marketplace in what is inherently a monopsonistic (one buyer) market. However, basic features of the procurement system remain in place: cost-based competitive bidding; cost-plus-fee contracting; close association between major contractors, DOD staff, and Congress; interlocking consortia of major contractors acting as prime and subcontractors to each other in different procurements; and a self-perpetuating system of technology development leading to procurement that is reinforced by the Independent Research and Development reimbursement mechanism. Can alternatives be found to one or more elements of this system that would improve the performance and lower the costs of defense procurement, or is the only alternative to seek to employ the very best people in both staff and management roles and to employ informed and aggressive oversight of their work?

- Does the implicit use of the linear pipeline model of innovation (basic research generates new ideas, which are explored in applied research, which are converted into weapons, systems, and devices by development projects) inhibit the effectiveness of the technology development process for defense systems?

Commercial industry has found that its own basic research programs are most useful when thought of as intelligence gathering and evaluation efforts to access new ideas developed elsewhere. A firm's own basic research is rarely the source of its important new concepts in terms of new marketable technologies. As a result, many firms have abandoned the pipeline model of R&D organization, and have both decentralized their technology development efforts and increased their programs of explicit outreach to external sources of new ideas via joint ventures, acquisition of new technology-based small firms, and participation in cooperative R&D activities with other firms or universities.

- Does the implementation of the pipeline model in the DOD budget formalism of 6.1, 6.2, etc. leave adequate opportunity for the Services and agencies to look beyond their own programs for new technology opportunities, or does it foreclose this kind of flexible outreach? Is this formalism only a budgeting convention, or does the associated management structure reinforce the "Not Invented Here" syndrome?
- Does the extensive and growing use of formal security classification in defense and defense-related R&D create unnecessary barriers to both defense technology development and the spin-off of defense technologies to the civilian sector?

Security classification is a necessary element of protection of critical defense-related technologies whose release would undermine the security of the nation. At the same time, however, classification brings costs. It typically compartmentalizes and isolates scientific and technical knowledge at all levels, separating fields, individual researchers, programs, Services, and contractors. However, one of the more significant modes of scientific and technical advance is serendipity, in which unexpected discoveries or unanticipated connections among scientific findings lead to new applications. Does the separation caused by classification inhibit this kind of unexpected advance? Might DOD researchers experience more opportunities for serendipitous discovery within the security classification envelope, if, for example, it became DOD policy to include persons from outside the immediate program area in its R&D program reviews, or to assure overlapping membership of outside scientific advisors on seemingly unrelated advisory panels?

Classification also inhibits access to defense technology by potential users of it in civilian technologies. In part, this may be unavoidable. However, perhaps DOD should explore mechanisms to search through its own store of scientific and technical information on a regular basis in the attempt to identify technologies that could be made available to the civilian sector. Some have pointed out that the defense contractors have an opportunity to identify such possibilities internally, although others have argued that the separation of functions between defense and non-defense operations within contractors minimizes the chances of this happening.

- Are DOD's RDT&E programs adequately coordinated with those of other R&D supporting agencies such as NASA, NSF, and DOE?

There is coordination among the agencies at a variety of levels, ranging from periodic meetings of agency senior R&D officials, to ad hoc meetings of program officers in specific areas of research. Also, external advisory panels can often help in making program officers aware of other agencies' programs, subject to limitations imposed by classification. Nevertheless, it may be useful to examine whether such coordination is effective in both avoiding unnecessary duplication (recognizing that not all duplication in R&D is either wasteful or unnecessary) and assuring that agency officials have access to all of the federally-supported science and engineering that might be of use in pursuing their missions.

- How might DOD better encourage spin-off of its scientific and engineering developments to the civilian arena in the service of commercial and public interests?

The Stevenson-Wydler Technology Innovation Act of 1980, and its amendment, the Federal Technology Transfer Act of 1986, require all Federal agencies, including DOD, to seek opportunities to spin-off their technologies for possible commercial or civilian public applications. In his January 1987 competitiveness message, President Reagan promised the promulgation of an Executive Order to implement the 1986 Act; this was released as E.O. 12591, "Facilitating Access to Science and Technology," on April 10, 1987. DOD has been one of the more aggressive agencies in implementing the letter and spirit of these Acts.

However, some believe that DOD could take a more active role in seeking opportunities to see that its store of technical knowledge and capabilities are used for civilian purpose, consonant with its defense mission. They would have DOD establish new mechanisms to scan DOD technologies and to identify those with potential application and seek out possible users of them. Others question whether DOD technologies in fact have much potential for application, either because they are designed for unique military functions, because their cost/performance characteristics are inappropriate for civilian use, or because in many areas civilian technology is actually more advanced than that used by DOD.

## H. Concluding Observations

The Department of Defense is a major supporter of research and development in American industry, providing between one-fourth and one-third of all of the funds that industry spends on R&D. It has, therefore, a responsibility to assure that these funds are spent wisely in support of the defense mission, and to assure that its presence does not unduly divert the private sector from its role as the provider of goods and services to strengthen the domestic economy and to make U.S. products competitive in world markets.

DOD support of technology development in industry is nearly 20 times larger in dollar terms than its support of university research. Arguably, then, while DOD has some impact on science and technology through its support of the supply of ideas and of trained scientists and engineers via the universities, it has a much greater impact through the demand it generates for ideas and human resources in the industrial marketplace. While it has been pointed out that DOD support of universities has helped to offset the demand it creates for scientific and technical personnel (See Chapter IX), its presence in the technical personnel market has helped to create the demand that encourages young people to choose careers in science or engineering.

At the current time, there is a great deal of congressional and public interest in taking advantage of defense-related technology and of DOD budget resources in particular to aid U.S. industry in regaining its international competitive edge. DOD is perceived by many as the "deep pocket" that can provide financial and technical assistance to civilian industries that are in competitive difficulty. Furthermore, the Nation has an interest in seeing that the defense industrial base is strong in the event of hostilities that might foreclose access to foreign sources of supply of materials, components, systems, or technologies.

Nevertheless, it is important to be cautious in employing defense resources in this way. It may divert DOD's attention from its core missions, which are to defend the nation in the event of military attack and to project American power around the globe. And, it is not clear that DOD procedures, policies, incentives, staffing, or culture are well-suited to working with commercial industry in fast-changing, cost-competitive markets. Finally, some attention should be paid to whether it would be in the long-term best interests of any nation for its defense establishment to play a major role in its civilian and commercial life, whatever the rationale and however well-intentioned the participants.

# CHAPTER VIII

# DOD SUPPORT OF INDEPENDENT RESEARCH AND DEVELOPMENT (IR&D) IN INDUSTRY: ISSUES AND IMPLICATIONS FOR FEDERAL SUPPORT OF CIVILIAN R&D [1]

## A. INTRODUCTION

Under certain circumstances, DOD allows its contractors to recover a portion of the costs of their own research and development activities through overhead payments on their cost-based [2] DOD procurement contracts. To distinguish them from RDT&E projects carried out under Government contracts, contractors' own research and development activities are denoted "Independent Research and Development," or IR&D.[3]

Precursors of the present IR&D mechanism date back to the 1940s, and the present implementaion of IR&D has its origins in cost and eligibility principles that evolved, often as a result of Congressional action, during the 1960s and 1970s.[4] In particular, P.L.

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[1] Prepared by Joan D. Winston and Christopher T. Hill. Ms. Winston is an Analyst, Office of Technology Assessment, U.S. Congress. Dr. Hill is Senior Specialist, Science and Technology Policy, Congressional Research Service. This work was carried out while Ms. Winston was a Senior Research Assistant, Office of Senior Specialists, Congressional Research Service.

[2] For the purposes of this chapter, the term "cost-based" contract refers to contract types *other* than firm-fixed-price. For the contract types referred to as cost-based, the contractor's compensation involves some consideration of the economic, risk, and cost issues involved in performance. For example, cost-based contracts would included fixed-price incentive contracts, cost-plus-incentive-fee contracts, and cost-plus-award-fee contracts.

Annually, the Defense Contract Audit Agency, DCAA, reports IR&D and "bid and proposal" (B&P) costs that are allocated, subject to a ceiling, each year to the contractors' cost-based contracts on which IR&D costs are explicitly recoverable as overhead. These data are based on the contractors' records; for multi-year contracts, costs are allocated on a current basis as they are incurred.

In its compilations of statistics on the sources of R&D funds in the United States, the National Science Foundation treats all IR&D as being paid for by the firm's own funds, and therefore does not include Government reimbursements for IR&D in Federal expenditures for R&D. (See Science Indicators 1982, NSF, 1983, p. 94.)

[3] There is some ambiguity in the literature's use of the phrase "Independent Research and Development." DOD and its contractors generally define all of the R&D activities funded by private DOD contractor firms as IR&D, whether their costs are recovered through overhead on Government contracts or are paid for by other contractor revenues. (This chapter uses this definition, unless otherwise noted.) On the other hand, in broader discussions of science policy, IR&D often refers only to that portion of DOD contractor's R&D expenditures that are actually recovered from DOD or other agencies through overhead allowances.

[4] For a more detailed history, as well as a description of the IR&D process and costs, see Defense-Related Independent Research and Development in Industry (CRS Report 85-205S) by Joan Dopico Winston.

Detailed descriptions of the evolution of the IR&D process in the context of defense procurement may also be found in: Holmfeld, John. Independent Research and Development: A Survey of the 1970 House and Senate Hearings (CRS 70-189 SP). p. 6-19; U.S. Congress. Senate. Committee on Armed Services, Subcommittee on Research and Development and Joint Economic Committee, Subcommittee on Priorities and Economy in Government. Hearings. Sept. 17, 24, 29, 1975. p. 447-477. (Hereinafter referred to as U.S. Senate, Sept. 1975.); and U.S. Congress. House Appropriations Committee. Surveys and Investigations Staff. Report on the Independent Research and Development Program of the Department of Defense. Washington, Mar. 2, 1982. p. 648-652. (Hereinafter referred to as Surveys and Investigations Staff, Mar. 1982.) Published in:

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91-441, which contains the modified Mansfield Amendment as section 204, also contains an explicit "potential military relevance" (PMR) criterion for IR&D in section 203.[5]

In comparison with DOD support of R&D using direct contracts, the IR&D mechanism is intended to strengthen DOD's technical base of contractors, to encourage more vigorous technical competition among contractors, to provide DOD with a broader spectrum of technical concepts and products, and to enable more timely responses to new technological breakthroughs or threats.

Essentially, the intent of the IR&D mechanism is to recognize that technology-based firms must invest in R&D to ensure their continuing capability to produce new and improved products and processes, and that the costs of doing R&D are legitimate costs of doing business. Permitting contractors to recover allowable IR&D costs through overhead payments is intended to establish for DOD contractors conditions that are similar to those faced by firms that sell to commercial buyers and that recover their costs of doing R&D in income from the sales of their products.

IR&D has been the focus of recurring criticisms and policy debates—particularly concerning the rationales behind the mechanism, its administration, and accountability to the Congress—especially during the past 20 years. Although contractors' IR&D costs allocated to overhead on DOD contracts are a small fraction of the DOD procurement budget (and a relatively small share of total overhead on these contracts), the total reimbursements to DOD contractors for IR&D are greater than the R&D budgets of all but the largest civilian R&D supporting agencies.

NASA also allows contractors to recover some IR&D costs, and closely follows DOD policies and procedures for IR&D. In view of its much smaller volume of industrial contracting, the NASA reimbursements for IR&D typically amount to less than 10 percent of the amount reimbursed by DOD. The Atomic Energy Commission (AEC) and then the Energy Research and Development Administration (ERDA) had followed a more restrictive IR&D policy up through the mid-1970s; the Department of Energy (DOE) does not reimburse IR&D at present.

This chapter first describes how IR&D costs are partially recovered by contractors via overhead on procurement contracts, and presents and analyzes data on the costs of IR&D to DOD. Then, a number of recurring policy issues regarding IR&D are summarized, including evaluation of the benefits of IR&D and consideration of alternative approaches to achieve the same objectives. The focus then shifts to the use of IR&D in the civilian agencies with large procurement contracts (NASA, the Atomic Energy Commission,

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U.S. Congress. House Appropriations Committee. Subcommittee on the Dept. of Defense. Part IV, Independent Research and Development. Hearings on the FY83 Budget, 97th Cong., 2d Sess., Apr. 28, 1982. p. 635-742. (Hereinafter referred to as House Appropriations Committee, Apr. 1982.)

[5] The modified Mansfield Amendment requires that any research project or study financed by funds appropriated to DOD must have a potential relationship to a military function or operation. Section 203(a) of P.L. 91-441 requires that no DOD funds are to be made available for "payment of IR&D . . . costs unless the work for which payment is made has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation." P.L. 91-441 also sets forth other conditions that must be satisfied in order for contractors to receive payments for IR&D costs.

and the Federal Aviation Administration). The chapter ends with an analysis of proposals that have been made to use a mechanism similar to IR&D to support some of the costs of maintaining the "research infrastructure" of major research universities.

## B. Costs of IR&D

### 1. MECHANISM OF IR&D REIMBURSEMENT

DOD reimburses contractors for a share of their IR&D costs through overhead payments on cost-based contracts in all parts of the procurement budget, not only on RDT&E contracts. Under the applicable regulations, contractors recover only a portion (DOD's "allocable share" [6]) of their allocable IR&D costs through overhead on DOD contracts, and recover a share of costs only for IR&D projects that are of "potential military relevance" (PMR).[7] DOD reports that in FY84 its major contractors incurred $5.1 billion of costs for IR&D efforts, of which $3.9 billion was accepted as allocable (eligible for recovery as overhead on or in the price of all the firms' contracts and sales). The DOD share of these allocable costs was about $1.9 billion, and this amount was allocated to overhead on DOD contracts.[8]

By comparison, the DOD appropriation for Research, Development, Test and Evaluation (RDT&E) in the same fiscal year was $26.9 billion.[9] Thus, DOD's allocable share of IR&D costs for FY84 (some $1.9 billion) was equivalent to seven percent of the total amount of RDT&E supported directly by DOD. Similarly, it was equivalent to 61 percent of the $3.1 billion FY84 DOD appropriation for the "technology base" (the sum of budget categories 6.1 and 6.2).[10] (IR&D reimbursements on procurement contracts, other than on RDT&E procurements, are not included in the DOD RDT&E expenditure totals.)

The overhead rates for IR&D cost recovery and the levels of costs accepted by the Government are determined by agreements negotiated in advance for large contractors and by formula for smaller contractors or for new contractors after the latter have established a base for the first year. These rates and levels are determined by a detailed annual review of contractors' IR&D project portfolios by DOD technical experts, and on a consideration by DOD acquisition officials of the reasonableness of the contractors' total expected IR&D expenditures, in light of their sales to DOD.

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[6] Through advance agreements that set a ceiling or, in some cases, by application of a formula, the DOD accepts a portion of a contractor's total incurred IR&D costs as allocable to *all* the contractor's business—his total sales and contracts. Since DOD contractors generally also have non-DOD contracts and sales, the (pro-rated) DOD portion of the accepted IR&D costs, allocated on the basis of sales, is less than the total accepted costs.

[7] The criterion that work funded by DOD must demonstrate a potential relationship to a military function or operation is stated in sections 203(a) and 204 of P.L. 91-441, The Armed Forces Appropriation Act of 1971.

[8] This figure includes approximately $0.15 billion in IR&D costs allocated to contracts for foreign military sales (FMS). In FY84, DOD's allocable share of IR&D costs amounted to about $1.7 billion exclusive of FMS. Unless otherwise noted in this report, the DOD allocable share of costs includes the passthrough of these costs to FMS contracts, which is typically less than 10 percent of the total allocable share.

[9] U.S. Dept. of Defense. Budget for Fiscal Year 1986. RDT&E Program (R-1). Washington, Feb 4, 1985. p. II.

[10] Ibid. The FY86 RDT&E conference agreement set a total FY86 ceiling for acceptable IR&D and B&P costs at $5.2 billion.

Negotiations regarding IR&D costs are carried out for entire firms that are heavily oriented toward DOD sales, or that are organized as a single production entity. For large and/or diversified firms, IR&D negotiations for cost recovery are carried out separately for each reporting division or operating group that has substantial DOD business. (In this chapter, the term "contractor" refers both to firms and to reporting divisions or operating groups with DOD business.)

Supporters of the IR&D mechanism argue that it allows achievement of the best balance between Government and contractor interests and expertise, and that it is an effective way to stimulate the continued development of new technologies related to agency missions. Critics, on the other hand, contend that IR&D is often inadequately administered and that because IR&D is not a line item in the DOD budget it is difficult for Congress to hold DOD accountable for these expenditures of public funds. These have been the major issues in a continuing series of investigations and reports on IR&D over at least the last two decades.

### 2. RELATIONSHIP OF IR&D TO BID AND PROPOSAL COSTS

Conceptually, IR&D costs are often considered together with the reimbursements that contractors can receive for portions of the "Bid and Proposal" (B&P) costs that they incur for engineering, analytical, and administrative efforts in support of proposals submitted to the Government. Current DOD regulations, in fact, permit contractors some latitude in shifting allowable costs between prenegotiated IR&D and B&P cost ceilings within a given year. However, in view of the different objectives of these two cost categories, they are treated separately in this chapter.

### 3. SOURCES OF IR&D COST DATA

The Defense Contract Audit Agency (DCAA) is mandated by section 203(c) of P.L. 91-441, The Armed Forces Appropriations Act of 1971, to report annually their statistics on the IR&D and B&P costs accepted by the Government and allocated to defense contracts.[11] Currently, DCAA reports IR&D and B&P costs for approximately 100 major contractors,[12] as well as for all other contractors that negotiate advance agreements for IR&D/B&P recovery.[13] DCAA obtains these data from the contractors' records, and uses estimates when data are unavailable, as, for example, when a contractor has not yet closed his books for the reporting year. A summary of the DCAA compilation of data on IR&D and B&P also appears in the Secretary of Defense's annual report to the Congress.

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[11] See, for example, Defense Contract Audit Agency. Summary of Indpendent Research and Development and Bid and Proposal Costs Incurred by Major Defense Contractors in the Years 1983 and 1984. Mar. 1985 (Hereinafter referred to as DCAA, Mar. 1985). The DCAA statistics include data from major defense contractors and other smaller defense contractors that negotiated advance agreements for IR&D and B&P. DCAA obtains the IR&D/B&P cost and sales data from contractors' records; where actual cost and sales data are not available, DCAA estimates are used. The DCAA data on IR&D and B&P typically come from some 230 to 290 reporting divisions and/or operating groups of the 90 to 100 contractors that DCAA audits and for which IR&D and B&P data are reported. The data for contractors' "total sales" refer only to the total commercial and Government sales of their reporting divisions and operating groups that receive IR&D/B&P reimbursements related to DOD contract sales. Sales by contractors' divisions not receiving IR&D/B&P reimbursements are excluded.

[12] Major contractors are those with an annual auditable volume of costs in excess of $40 million or that required at least 5,000 staff hours of DCAA direct audit work a year.

[13] A large and growing fraction of all IR&D is carried out pursuant to negotiated advance agreements. The percentage of contractors (firms, or reporting divisions and/or operating groups) included in the DCAA summary that negotiated advance agreements rose from around 80 percent in FY 1974 to almost 90 percent in FY 1984, and the percentage of IR&D/B&P costs (dollars) recovered from DOD subject to advance agreements rose from around 96 percent in FY 1974 to almost 99 percent in FY 1984.

Data are available neither for the costs of all IR&D performed by industry nor for the share of these costs recovered from DOD. The reasons for and the implications of this situation have been the subject of congressional hearings [14] and of independent analyses of the IR&D/B&P process.[15] Although a large proportion of the total IR&D/B&P cost recovery is captured in DCAA's reports to the Congress, DOD has estimated that in FY 1979, the IR&D/B&P costs recovered from DOD without being reported by DCAA ranged from $35 million to $70 million; that is, three to six percent of the amount paid by DOD for IR&D/B&P was not included in the DCAA report.[16]

One reason that some IR&D costs recovered from DOD are not reported is that some IR&D costs are recovered by contractors in their income from items purchased at a firm fixed price or on a competitive basis, on which overhead costs are not explicit. (This is similar to the situation when DOD buys any item in the open market whose price happens to include recovery of the producer's R&D expenses.) In addition, not all contractors that recover IR&D costs have "auditable workloads" and, therefore, may only be monitored by DCAA every two or three years rather than yearly.[17] Also, the figures reported by DCAA as the "DOD share" of allocable IR&D costs for a given year are for costs allocated to DOD contracts that year, based on the contract's books. This figure is roughly equivalent to the actual "reimbursements" made to contractors, but determining actual reimbursements requires detailed examiniations of historical records and contracts; this is not usually done. Finally, DCAA specifically excludes construction companies, educational institutions, foreign contractors and overseas operations of U.S. contractors, insurance companies, marine transport contractors, and military medical contractors from the summary because these types of contracting activities incur nominal or no IR&D/B&P costs.

### 4. IR&D COST DATA, 1964–1984

Data on IR&D costs and reimbursements over the last two decades were complied for this report from two sources. For the period 1964–1974, a compilation by the IR&D Task Force of the Defense Science Board was used. For the period 1974-1984, CRS compiled data from the DCAA summary annual reports to Congress.

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[14] Testimony of R. DeLauer and J. Brown in House Appropriations Comm., Apr. 1982, p. 688-741.

[15] Reppy, Judith, and F.A. Long. The Pentagon's Program of IR&D: The Need for Reform. Bulletin of the Atomic Scientists, v. 32, Jan. 1976: p. 30-36. (hereinafter referred to as Reppy and Long, Jan 1976.); Reppy, Judith , and F.A. Long. U.S. Military R&D: A Set of Questions. Bulletin of the Atomic Scientists, v. 34, May 1978: p. 34-41. (Hereinafter referred to as Reppy and Long, May 1978.); Long, F.A., and Judith Reppy. The Decision Process for U.S. Military R&D. In, Review of U.S. Military Research and Development 1984, ed. by Kosta Tsipis and Penny Janeway. Pergamon-Brassey's, 1984. p. 8–11.

[16] Testimony of J. Brown in House Appropriations Committee, Apr. 1982, p. 714.

[17] Ibid., p. 702–703.

Table I, taken from a 1975 report of the Defense Science Board IR&D Task Force, shows IR&D and related cost statistics for FY 1964-1974.[18] Over this 11-year period, the reported ratio of contractors' DOD sales to total sales declined from 70 percent to 54 percent, with an average of 62 percent. At the same time, the amount of IR&D, B&P (and OTE) costs allocated to DOD contracts fell as a percentage of total costs incurred by the contractors for these purposes but rose from 2.75 percent of DOD sales in 1964 to 3.73 percent of DOD sales in 1974. The contractors reported incurred IR&D, B&P (and OTE) costs amounting to 3.63 percent of their total sales in 1964, compared with 4.19 percent in 1974. Thus, incurred IR&D, B&P (and OTE) costs as a percentage of sales increased more rapidly for defense sales than for total sales (defense plus commercial) by the contractor during this period.

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[18] A revision of cost principles that became effective in FY71 changed definitions of IR&D/B&P costs to include costs reported as "Other Technical Effort" by DCAA in earlier years

TABLE I.
STATISTICS RELATING TO IR&D, B&P, and OTE FOR MAJOR DEFENSE CONTRACTORS, 1964-1974
(dollar amounts in millions)

| | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sales | | | | | | | | | | | |
| Total Government and commercial | 23,470 | 24,054 | 26,438 | 34,167 | 36,954 | 36,430 | 32,519 | 32,065 | 30,577 | 37,635 | 40,405 |
| Total DOD only | 16,442 | 15,644 | 17,889 | 21,371 | 22,275 | 22,692 | 21,315 | 19,568 | 19,117 | 21,148 | 21,690 |
| % DOD sales to total sales | 70% | 65 | 63 | 63 | 61 | 62 | 65 | 61 | 63 | 56 | 54 |
| IR&D | | | | | | | | | | | |
| Total industry cost incurred | 419 | 439 | 502 | 591 | 752 | 808 | 753 | 703 | 936 | 1,164 | 1,148 |
| Total reimbursed on DOD contracts | 199 | 198 | 224 | 277 | 333 | 389 | 376 | 354 | 392 | 441 | 457 |
| Amount reimbursed on DOD contracts | | | | | | | | | | | |
| As a % of total incurred | 47% | 45 | 45 | 47 | 44 | 48 | 50 | 50 | 42 | 38 | 40 |
| As a % of DOD sales | 1.21% | 1.26 | 1.25 | 1.30 | 1.46 | 1.73 | 1.76 | 1.86 | 2.05 | 2.09 | 2.17 |
| B&P | | | | | | | | | | | |
| Total industry cost incurred | 252 | 277 | 315 | 338 | 387 | 426 | 414 | 428 | 469 | 553 | 546 |
| Total reimbursed on DOD contracts | 182 | 186 | 202 | 230 | 275 | 286 | 278 | 265 | 306 | 360 | 351 |
| Amount reimbursed on DOD contracts | | | | | | | | | | | |
| As a % of total incurred | 72% | 67 | 64 | 68 | 71 | 67 | 67 | 62 | 65 | 65 | 64 |
| As a % of DOD sales | 1.11% | 1.19 | 1.13 | 1.08 | 1.23 | 1.26 | 1.30 | 1.35 | 1.60 | 1.70 | 1.62 |
| OTE | | | | | | | | | | | |
| Total industry cost incurred | 182 | 237 | 238 | 292 | 252 | 178 | 151 | 0 | 0 | 0 | 0 |
| Total reimbursed on DOD contracts | 71 | 76 | 91 | 92 | 77 | 79 | 60 | 0 | 0 | 0 | 0 |
| Amount reimbursed on DOD contracts | | | | | | | | | | | |
| As a % of total incurred | 39% | 32 | 38 | 32 | 31 | 44 | 40 | - | - | - | - |
| As a % of DOD sales | 0.43% | 0.49 | 0.51 | 0.43 | 0.35 | 0.35 | 0.28 | - | - | - | - |
| Grand Total | | | | | | | | | | | |
| IR&D, B&P, OTE incurred | 853 | 953 | 1,055 | 1,221 | 1,391 | 1,412 | 1,318 | 1,131 | 1,405 | 1,717 | 1,694 |
| Total reimbursed by DOD | 452 | 460 | 517 | 599 | 685 | 754 | 714 | 619 | 698 | 801 | 808 |
| Amount reimbursed by DOD | | | | | | | | | | | |
| As a % of total incurred | 53% | 48 | 49 | 49 | 49 | 53 | 54 | 55 | 50 | 47 | 48 |
| As a % of DOD sales | 2.75% | 2.94 | 2.89 | 2.80 | 3.07 | 3.32 | 3.35 | 3.16 | 3.65 | 3.79 | 3.73 |
| Total incurred costs as a % of total sales | 3.63% | 3.96 | 3.71 | 3.57 | 3.76 | 3.88 | 4.05 | 3.52 | 4.59 | 4.56 | 4.19 |

SOURCE: Annual DCAA Report, "Summary of IR&D and B&P Costs Incurred by Major Defense Contractors," as compiled in Defense Science Board IR&D Task Force. An Analysis of Independent Research and Development/Bid and Proposal (IR&D/B&P). Washington, D.C., Office of Defense Research and Engineering, Mar. 1975. p. 37.

TABLE II.
STATISTICS RELATING TO IR&D AND B&P, 1974-1984
(millions of dollars)

| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IR&D Costs | | | | | | | | | | | |
| Incurred by contractors | 1175 | 1235 | 1388 | 1569 | 1788 | 2132 | 2373 | 2796 | 3654 | 4017 | 5115 |
| Accepted by Government for allocation to all business | 921 | 1015 | 1061 | 1199 | 1365 | 1529 | 1728 | 2039 | 2821 | 1961 | 3866 |
| Share allocated to DOD contracts, excluding FMS | NA | NA | NA | 524 | 578 | 651 | 745 | 936 | 1193 | 1473 | 1718 |
| Share allocated to FMS | NA | NA | NA | 74 | 65 | 64 | 67 | 120 | 145 | 128 | 145 |
| Total DOD share, including FMS | 467 | 501 | 544 | 598 | 643 | 715 | 812 | 1056 | 1338 | 1601 | 1863 |
| B&P Costs | | | | | | | | | | | |
| Incurred by contractors | 551 | 604 | 678 | 738 | 780 | 846 | 1011 | 1155 | 1349 | 1570 | 1917 |
| Accepted by Government for allocation to all business | 506 | 539 | 577 | 607 | 662 | 729 | 872 | 1007 | 1136 | 1271 | 1461 |
| Share allocated to DOD contracts, excluding FMS | NA | NA | NA | 393 | 430 | 483 | 561 | 642 | 762 | 908 | 1060 |
| Share allocated to FMS | NA | NA | NA | 48 | 40 | 34 | 33 | 47 | 52 | 58 | 62 |
| Total DOD share, including FMS | 356 | 381 | 407 | 441 | 470 | 517 | 594 | 689 | 814 | 966 | 1122 |
| Combined IR&D and B&P Costs | | | | | | | | | | | |
| Incurred by contractors | 1726 | 1839 | 2066 | 2307 | 2568 | 2978 | 3384 | 3951 | 5003 | 5587 | 7032 |
| Accepted by Government for allocation to all business | 1427 | 1554 | 1638 | 1806 | 2027 | 2258 | 2600 | 3046 | 3957 | 4232 | 5327 |
| Share allocated to DOD contracts, excluding FMS | 777 | 811 | 836 | 917 | 1008 | 1134 | 1306 | 1578 | 1955 | 2381 | 2778 |
| Share allocated to FMS | 46 | 71 | 115 | 122 | 105 | 98 | 100 | 167 | 197 | 186 | 207 |
| Total DOD share, including FMS | 823 | 882 | 951 | 1039 | 1113 | 1232 | 1406 | 1745 | 2152 | 2567 | 2985 |
| Contractor Sales 1/ | | | | | | | | | | | |
| Total Government and commercial | 43175 | 46024 | 47429 | 52442 | 62079 | 73373 | 84434 | 95716 | 105577 | 119154 | 135166 |
| DOD except FMS | 20672 | 22412 | 23415 | 26130 | 28299 | 32858 | 40602 | 49277 | 58844 | 72285 | 83100 |
| DOD FMS | 1448 | 2159 | 3418 | 3801 | 3594 | 2645 | 2710 | 4320 | 4966 | 4951 | 5341 |
| Total DOD sales | 22120 | 24571 | 26833 | 29931 | 31893 | 35503 | 43312 | 53597 | 63810 | 77236 | 88441 |
| Number of Contractor Divisions Included 2/ | 259 | 258 | 235 | 233 | 239 | 248 | 258 | 277 | 276 | 287 | 287 |
| Number with advance agreements | 206 | 212 | 205 | 202 | 206 | 218 | 229 | 233 | 245 | 249 | 258 |
| Number without advance agreements | 53 | 46 | 30 | 31 | 33 | 30 | 29 | 44 | 31 | 38 | 29 |
| Percent with advance agreements | 79.5% | 82.2% | 87.2% | 86.7% | 86.2% | 87.9% | 88.8% | 84.1% | 88.8% | 86.8% | 89.9% |
| Total DOD Share ($) 2/ | | | | | | | | | | | |
| Percent IR&D under advance agreements | 97.2% | 97.6% | 98.7% | 99.0% | 99.1% | 99.3% | 99.5% | 99.2% | 99.5% | 98.4% | 99.0% |
| Percent B&P under advance agreements | 94.7% | 96.3% | 97.5% | 98.6% | 98.5% | 97.7% | 98.3% | 97.4% | 98.0% | 97.2% | 97.9% |
| Percent IR&D and B&P under advance agreements | 96.1% | 97.1% | 98.2% | 98.8% | 98.8% | 98.6% | 99.0% | 98.5% | 98.9% | 97.9% | 98.6% |

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1/ Note that sales data reflect only those activities of the operating groups or reporting division having DOD business for which DCAA reports IR&D statistics.

2/ CRS calculations from DCAA data.

SOURCE: Summary of Independent Research and Development and Bid and Proposal Cost Incurred by Major Contractors. Prepared by Defense Contract Audit Agency.

Table II presents a summary of data on costs of IR&D and B&P for FY 1974-1984 compiled by CRS from the DCAA summary annual reports. Changes in patterns of costs and reimbursements can be seen by comparing selected average characteristics of the data across the two decades, as illustrated in Table III.

TABLE III.—COMPARISON OF IR&D REIMBURSEMENT OVER THE LAST TWO DECADES

[Decades (fiscal years)]

| | Change from 1964-73 | Change from 1974-84 |
|---|---|---|
| DOD reimbursements for IR&D | $199 to $441 million | $467 to $1,863 million |
| IR&D reimbursements as a percentage of sales to DOD | 1.2 to 2.1 percent | 2.1 to 2.0 percent |
| IR&D reimbursements as a percentage of total incurred cost | 47 to 38 percent | 40 to 36 percent |

Source: Data in Tables I and II.

## 5. ANALYSIS OF IR&D DATA BY INDUSTRY AND PURPOSE

The DCAA report to the Congress on IR&D and B&P does not provide any breakdowns of IR&D reimbursements by firm, industry class, or technical area of work. One of the few publicly available breakdowns of major IR&D performers by three-digit SIC class, is based on unpublished data collected by the Office of the Assistant Secretary for Defense (Installations and Logistics) for FY 1973.[19] These data showed that of the top 25 IR&D companies, 13 were in the aircraft industry, six in electrical equipment, three in motor vehicles, two in office and computing machinery, and one in optical measuring and control devices. Of the top 50, 18 were in electrical equipment and 16 in aircraft. A more recent breakdown of major IR&D contractors by SIC code could not be obtained; nevertheless, while the distribution may have changed since 1973, the aircraft/missile and electrical equipment industries are likely to have remained large IR&D performers.

Among the top 12 DOD prime contractors in 1973, the rank orderings by dollar value of prime contracts, RTD&E contracts, and IR&D payments differed somewhat. However, 11 of the top 12 prime contractors were among the top 12 RDT&E contractors and nine were among the top 12 recipients of IR&D payments (including IR&D payments on subcontracts received by these contractors).[20]

Data on the distribution of IR&D effort by category of technical work is also not routinely compiled or made available to the public. A 1974 industry study by the Tri-Association Ad Hoc Committee on IR&D and B&P [21] estimated that the FY 1972 IR&D efforts, for which over $400 million in costs was allocated to DOD contracts, corresponded to activities distributed as follows:

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[19] Reppy, Judith. Defense Department Payment for "Company-Financed" R&D. Research Policy, v. 6, 1977: p. 396-410; table 2, p. 405. (Hereinafter referred to as Reppy, 1977.)

[20] Data from the Offices of the Assistant Secretaries of Defense (Comptroller, Installations and Logistics) given in Reppy and Long, Jan. 1976, table 4. In FY 1973, the top five recipients of IR&D payments were United Technologies, General Electric, Boeing, Raytheon, and Rockwell International. These firms ranked eleventh, sixth, fourth, ninth, and third, respectively, for RDT&E contracts and eighth, second, third, eleventh, and tenth, respectively, for prime DOD contracts in 1973.

[21] Tri-Association Ad Hoc Committee on IR&D and B&P (Aerospace Industries Association of America, Inc.; Electronic Industries Association; National Security Industrial Association). Technical Papers on Independent Research and Development and Bid and Proposal Efforts. Washington, D.C., Mar. 1974. p. 32. (Hereinafter referred to as Tri-Association, 1974.)

basic research—less than 5%;
applied research—approximately 30%;
development—approximately 50%; and
studies—approximately 15%;

The Tri-Association Committee noted that a task-by-task analysis of information in the DOD IR&D Data Bank could provide more precise figures, but it attempted no such study.[22] This breakdown suggests that the distribution of IR&D efforts by technical function is similar to that for RDT&E in that only a small fraction is devoted to basic research and that the bulk of the funds are used for development. DOD RDT&E spending totalling $7.8 billion was distributed as follows for fiscal year 1972: [23]

| | *Percent* |
|---|---|
| Research | 4.3 |
| Exploratory Development | 13.7 |
| Advanced Development | 19.3 |
| Engineering Development | 23.9 |
| Management Support | 13.6 |
| Emergency Fund | 0.6 |
| Operational Systems Development | 24.6 |

### 6. TRENDS IN DOD SHARES OF ALLOCATED IR&D COSTS

Trends over the last decade in shares of allocated IR&D costs reimbursed by DOD, and their relationships to sales and RDT&E spending are shown in Table IV, based on the DCAA data in Table II. During the period 1974-1984, between 72 and 82 percent of the actual IR&D costs incurred by contractors have been accepted for allocation, but only about one-half of the accepted costs—that is, about 40 percent of the actual costs—have been allocated to DOD contracts during this period. Similarly, the share of IR&D and B&P costs taken together allocated to DOD contracts has ranged from 54 to 61 percent of the accepted costs, and from 41 to 48 percent of the contractors' actual costs. During the same period, these contractors' aggregate sales to DOD, including foreign military sales (FMS), ranged from 48 to 65 percent of their aggregate sales to all customers.

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[22] Ibid.

[23] Statement by the Director of Defense Research and Engineering, Dr. John S. Foster, Jr., on the FY 1973 Defense RDT&E Program before the Armed Services Committee, U.S. Senate, 92d Congress, on Feb. 17, 1972.

## TABLE IV.
## DOD SHARES OF ALLOCATED COSTS, 1974-1984

| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IR&D Costs | | | | | | | | | | | |
| Accepted for allocation to all business as % of incurred costs | 78.4% | 82.2% | 76.4% | 76.4% | 76.3% | 71.7% | 72.8% | 72.9% | 77.2% | 73.7% | 75.6% |
| Total DOD share of allocable costs | | | | | | | | | | | |
| as % of incurred costs | 39.7% | 40.6% | 39.2% | 38.1% | 36.0% | 33.5% | 34.2% | 37.8% | 36.6% | 39.9% | 36.4% |
| as % of accepted for allocation to all business | 50.7% | 49.4% | 51.3% | 49.9% | 47.1% | 46.8% | 47.0% | 51.8% | 47.4% | 54.1% | 48.2% |
| B&P Costs | | | | | | | | | | | |
| Accepted for allocation to all business as % of incurred costs | 91.8% | 89.2% | 85.1% | 82.2% | 84.9% | 86.2% | 86.3% | 87.2% | 84.2% | 81.0% | 76.2% |
| Total DOD share of allocable costs | | | | | | | | | | | |
| as % of incurred costs | 64.6% | 63.1% | 60.0% | 59.8% | 60.3% | 61.1% | 58.8% | 59.7% | 60.3% | 61.5% | 58.5% |
| as % of accepted for allocation to all business | 70.4% | 70.7% | 70.5% | 72.7% | 71.0% | 70.9% | 68.1% | 68.4% | 71.7% | 76.0% | 76.8% |
| Combined IR&D and B&P Costs | | | | | | | | | | | |
| Total DOD share of allocable costs | | | | | | | | | | | |
| as % of incurred costs | 47.7% | 48.0% | 46.0% | 45.0% | 43.3% | 41.4% | 41.5% | 44.2% | 43.0% | 45.9% | 42.4% |
| as % of accepted for allocation to all business | 57.7% | 56.8% | 58.1% | 57.5% | 54.9% | 54.6% | 54.1% | 57.3% | 54.4% | 60.7% | 56.0% |
| % of DOD share of allocable costs allocated to FMS | 5.6% | 8.0% | 12.1% | 11.7% | 9.4% | 8.0% | 7.1% | 9.6% | 9.2% | 7.2% | 6.9% |
| Contractor Sales 1/ | | | | | | | | | | | |
| % of DOD including FMS | 51.2% | 53.4% | 56.6% | 57.1% | 51.4% | 48.4% | 51.3% | 56.0% | 60.4% | 64.8% | 65.4% |
| % of DOD sales that are FMS | 6.5% | 8.8% | 12.7% | 12.7% | 11.3% | 7.5% | 6.3% | 8.1% | 7.8% | 6.4% | 6.0% |
| Contractor Performance | | | | | | | | | | | |
| IR&D costs incurred as % of total sales | 2.7% | 2.7% | 2.9% | 3.0% | 2.9% | 2.9% | 2.8% | 2.9% | 3.5% | 3.4% | 3.8% |
| IR&D costs allocated to DOD contracts as % of total sales to DOD | 2.1% | 2.0% | 2.0% | 2.0% | 2.0% | 2.0% | 1.9% | 2.0% | 2.1% | 2.1% | 2.1% |
| IR&D costs allocated to FMS as % of FMS sales | NA | NA | NA | 1.9% | 1.8% | 2.4% | 2.5% | 2.8% | 2.9% | 2.6% | 2.7% |
| IR&D/B&P costs incurred as % of total sales | 4.0% | 4.0% | 4.4% | 4.4% | 4.1% | 4.1% | 4.0% | 4.1% | 4.7% | 4.7% | 5.2% |
| IR&D/B&P costs allocated to DOD contracts as % of sales to DOD | 3.7% | 3.6% | 3.5% | 3.5% | 3.5% | 3.5% | 3.2% | 3.3% | 3.4% | 3.3% | 3.4% |
| IR&D/B&P allocated to FMS as % of FMS sales | 3.2% | 3.3% | 3.4% | 3.2% | 2.9% | 3.7% | 3.7% | 3.9% | 4.0% | 3.8 | 3.9% |

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1/ Sales figures are only for divisions or groups that have DOD business and for which DCAA reports on IR&D. For large, diversified firms, sales figures do not reflect sales for entire firm.

SOURCE: CRS calculations from DCAA data in Table II.

Contractors' incurred IR&D costs as a percentage of total sales rose from 2.7 percent in FY 1974 to 3.8 percent in FY 1984, while IR&D costs allocated to DOD contracts held at around 2.0 percent of contractors' sales to DOD (including FMS) during this period. Over the period FY 1977-84, IR&D costs recovered from FMS increased as a percentage of FMS sales, but IR&D costs recovered from FMS have been less than 10 percent of the total IR&D costs recovered from DOD. The reimbursement-to-sales ratio has been higher for FMS sales than for sales to DOD itself since FY 1979.[24]

Contractors' incurred IR&D and B&P costs combined rose from four percent of total sales in FY 1974 to 5.2 percent in FY 1984. The percentage of these costs allocated to DOD contracts fell slightly as a percentage of sales to DOD, going from 3.7 percent of sales to DOD in FY 1974 to 3.4 percent in FY 1984. For FY84, IR&D costs incurred by these 287 divisions and/or groups totalled $5.1 billion. Of this amount, $3.87 billion, or 76 percent, was accepted as allocable. The DOD share of these allocable costs was $1.86 billion, including $145 million from contracts for foreign military sales. The DOD share of allocable costs for IR&D and B&P combined, including costs recovered through foreign military sales, was $2.99 billion in FY84, based on $88.4 billion sales to DOD. The ratio of DOD sales to all sales was 65.4 percent, and the shares of incurred and accepted costs of IR&D that were allocated to DOD contracts were 36.4 and 48.2 percent, respectively. For B&P, the incurred and allocated shares were 58.5 and 76.8 percent, respectively. The DOD share of allocable costs for IR&D ($1.86 billion) is equivalent to 6.9 percent of the FY84 appropriation for RDT&E of $26.9 billion, or to 61 percent of the FY84 appropriation for the "technology base" (DOD budget categories 6.1 and 6.2) of $3.06 billion.[25]

### C. Recurring Policy Issues Regarding IR&D

Recurring policy issues concerning the intent, execution, and oversight of IR&D/B&P were the subject of congressional hearings and associated legislative branch studies in 1970 and 1975, and have also been the focus of studies by the DOD, industry, and independent scholars.[26]

More recently, issues in IR&D were the subject of House Appropriations Committee hearings on the FY83 budget[27] and of a report in 1981 by the National Research Council (NRC) to the Office of Science and Technology Policy (OSTP).[28]

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[24] IR&D and B&P cost recovery from FMS is essentially a "pass through" via DOD of funds from foreign government purchasers to the contractors.

[25] U.S. Dept. of Defense. Budget for Fiscal Year 1985. R,D,T,&E Program (R-1). Washington, Feb. 1, 1984. p. II.

[26] Examples of these are: U.S. Congress. House. Armed Services Investigating Subcommittee. Committee on Armed Services. Hearings on Independent Research and Development, Feb.-Mar. 1970. Testimony of K. Harr, President, Aerospace Industries of America, Inc. p. 60-77. (Hereinafter referred to as House, Feb.-Mar. 1970); United States General Accounting Office. Report to the Subcommittee on Research and Development, Senate Committee on Armed Services and Subcommittee on Priorities and Economy in Government, Joint Economic Committee. Contractors' Independent Research and Development Program—Issues and Alternatives, June 5, 1975. p. 10. (Hereinafter referred to as GAO, June 5, 1975.); An Analysis of Independent Research and Development/Bid and Proposal (IR&D/B&P). The IR&D Task Force of the Defense Science Board. Office of the Director of Defense Research and Engineering. Washington, D.C., Mar. 1975. p. ix. (Hereinafter referred to as Defense Science Board 1975.); Tri-Association, 1974; Testimony of Long and Reppy in U.S. Senate, Sept. 1975, p. 714-723; Reppy and Long, Jan. 1976; Reppy 1977; and Institute of Electrical and Electronics Engineering. Independent R&D: Three Viewpoints, William Proxmire, D. Max Heller, and Malcolm R. Currie. IEEE Spectrum, v. 13, Nov. 1976: p. 50-53.

[27] House Appropriations Committee, Apr. 1982, Part IV, p. 635-742.

Most recently, in 1985 the House Committee on Appropriations concluded that, in view of the multibillion dollar size of the IR&D/B&P costs accepted by the Government[29] and the current emphasis on examining and reforming DOD procurement practices, a review of IR&D and B&P was in order.[30] The report directed DOD to prepare an "independent assessment of the justification, tangible benefits, specific costs, management and administrative structure of IR&D/B&P . . . to be available in conjunction with the Committee's examination of the fiscal year 1987 budget request."[31]

The NRC study followed from a request in the Senate Appropriations Committee's report on the Federal budget for FY79 that OSTP examine the IR&D programs of DOD and NASA.[32] The 1981 NRC study reported on the first phase of what OSTP defined as a two-phase program: (1) to develop and outline a plan for a comprehensive study of IR&D, raising issues and proposing in-depth research methods but without judging the merits of IR&D, and (2) to carry out the comprehensive assessment. After the phase-I report on issues and methodology was issued in January 1981, NRC was not asked by OSTP to carry out the comprehensive assessment.[33]

Chapter 4 of the NRC report provides a synthesis of recurrent, enduring issues, which its Committee on IR&D Issues grouped into three issue areas: program effectiveness in furthering its official objectives, market issues, and accountability and management issues. The lengthy discussion of issues for in-depth study by NRC[34] is summarized here, since the issues remain current and germane to any new examination of IR&D and/or B&P. Among the essential features of the *effectiveness* issues noted by the NRC are:

(i) Whether IR&D serves as a stimulus to innovation (a primary objective of the program), resulting in more innovative proposals in response to DOD requests and encouraging contractors to perform relatively long-term R&D work, rather than concentrating only on near-term or contract work. Critics of R&D have contended that IR&D funds may often be used on short-term projects or that work may be influenced by program managers' emphases on near-term objectives for contract work.

(ii) Whether contractors' abilities to reallocate funds between IR&D and B&P work (so long as total costs remain under the negotiated ceiling) result in a bias toward near-term B&P work during years when contract funding is low, thus retarding innovation in the long run.

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[28] Committee on Independent Research and Development Issues, Assembly of Engineering, National Research Council. The DOD-NASA Independent Research and Development Program: Issues and Methodology for an In-Depth Study. NTIS PB82192741. Washington, DC, National Academy Press, 1981. p. 16-19. (Hereinafter referred to as NRC, Mar. 1981.)

[29] Anticipated to be on the order of $5.2 billion for FY85 and FY86.

[30] U.S. Congress. House. Committee on Appropriations. Department of Defense Appropriations Bill, 1986. Report to accompany H.R. 3629. October 24, 1985. p. 284-285.

[31] Ibid. p. 285. The report is being prepared for DOD under contract by the Rand corporation. Release of the report has been delayed as a result of formalities required to obtain access to contractor-confidential data for the Rand study group. (Susan Bodilly, Rand Corp., personal communication, March 10, 1987.)

[32] NRC, Mar. 1981, p. iii.

[33] Dr. Joel Goldhar, study director for the NRC report. Personal communication, Aug. 1, 1985.

[34] NRC, Mar. 1981, p. 27-35.

(iii) Whether IR&D does, in fact, increase technological competition among bidders and does induce more than one contractor to maintain the ability to respond quickly to Government requests for proposals in a given technical area.

(iv) Whether enhancing contractors' stability, by helping them to diversify and develop a broad base of technical products, produces a strong group of contractors and whether this benefit outweighs the potential anticompetitive effects of maintaining *current* Government contractors' funding bases.

Among the essential features of the *market issues* noted by NRC are:

(i) The extent to which IR&D funding serves as a barrier to entry into or exit from the defense and space markets. Although IR&D projects can be proposed by non-Government contractors and B&P costs are recoverable for solicited as well as unsolicited proposals, costs are only recovered as overhead on Government contracts. Current contractors may gain advantages from the IR&D/B&P system, in terms of reduced risks and a more secure flow of R&D funds, that are not available to non-contractors.

(ii) The extent to which the method of allocating IR&D costs to the contractors' pool of Government and commercial sales produces net biases in favor of the contractors (or in favor of the Government).

(iii) The extent to which IR&D funds can be diverted and used to cross-subsidize a contractor's commercial interests.[35]

(iv) The extent to which the current system of patent rights (whereby patent rights for IR&D work belong to the contractor, although the Government is entitled to free use of the invention in performing Government contract work) is fair to the contractor and to the Government, and the extent to which altering these rights would affect companies' participation in IR&D work.

Among the features of the *accountability and management* issues noted by NRC are:

(i) Cost control and selection of IR&D projects by DOD and NASA managers;

(ii) Costs of more comprehensive monitoring of IR&D and a comparison of monitoring costs to net benefits from monitoring;

(iii) Quality of technical evaluations of proposed IR&D projects and qualifications of evaluators; [36]

(iv) The extent to which the PMR (potential military relevance) requirement is uniformly applied;

(v) The extent to which the PMR requirement adversely affects NASA's civilian space interests;

(vi) Costs versus benefits of on-site technical evaluations;

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[35] See also: General Accounting Office. Independent Research and Development Allocations Should Not Absorb Costs of Commercial Development Work. Dec. 10, 1974.

[36] See also: General Accounting Office. High Turnover of Managers Directing Major Research and Development Projects (Department of the Army). Aug. 31, 1970; and Surveys and Investigations Staff, Mar. 1982, p. 662–69.

(vii) Whether the weight given technical evaluations in negotiating advance agreements is optimal;

(viii) Intra-firm management of IR&D and the degree to which firms' criteria for project selection match the stated goals for IR&D; and

(ix) Whether the services do indeed negotiate uniformly, and whether different industries [e.g., submarine builders and missile builders] are treated equitably in negotiations.

A major issue of recurring congressional interest has been whether IR&D should be a budget line-item, which might provide for more visibility and accountability despite higher administrative costs,[37] or whether other alternatives to the overhead-based method of reimbursing IR&D costs should be used. The 1975 GAO report [38] examined 14 alternative approaches, including elimination of IR&D and B&P as allowable costs, and funding of IR&D/B&P costs through a category of separate contracts whose costs would be shown as a budget line item. GAO requested comments on the alternatives from 18 representatives of Government, industry, academia and one industry association, all of whom had had direct experience with IR&D. Their responses to the alternatives differed, and GAO found that none of the proposed alternatives was preferred to the current system.[39] One recurring criticism of direct contract funding for IR&D is that it would encourage DOD to exert control over contractors' in-house R&D and thus reduce both the diversity in the R&D they conduct and their flexibility to respond to shifting needs and opportunities.[40] Also, the high administrative costs of line-item funding were frequently cited as a disadvantage of this approach.[41] Eliminating IR&D/B&P entirely received unfavorable comments from industry and from DOD and NASA representatives, who stated that IR&D/B&P provided valuable contributions to technical diversity, competition, quality, and long-term efficiency.[42]

## D. Measuring the Outcomes From IR&D

In light of the importance attached to the IR&D mechanism, the substantial expenditures that support it, and the recurring questions raised about its administration, a number of studies have attempted to assess the outcomes and effectiveness of IR&D. However, none of the reports has been able to reach firm conclusions.

Evaluating the returns to R&D expenditures has proven to be very difficult, either before or after the R&D is carried out.[43] Significant problems arise, both in measurement and in analysis, including problems in generalizing from case studies, problems of aggregation and measurement of inputs to and outputs from R&D,

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[37] General Accounting Office, Department of Defense: Feasibility of Treating Contractors' Independent Research and Development Costs as a Budget Line Item. GAO, Mar. 8, 1971.

[38] GAO, June 5, 1975, p. 48–70.

[39] Ibid., p. 52, 69–70.

[40] Activities whose costs are charged to a firm's IR&D and/or B&P accounts must not be "sponsored by a grant, nor required in performing a contract" (FAR 31.001); therefore, IR&D and/or B&P accounts may not be used to cross-subsidize the firm's other contract work,

[41] See, for example, GAO, June 5, 1975, p. 50–51.

[42] Ibid., p. 68–71.

[43] United States Office of Technology Assessment, Research Funding as an Investment; Can We Measure the Returns?, Technical Memorandum OTA-TM-SET-36, 1986.

the fact that the productivity of R&D investments is affected by prior R&D findings, the lag inherent in incorporating new findings into useful discoveries, and "spillovers" from one technical field to another. These problems in evaluating the contributions of R&D suggest that definitive results from such studies are unlikely under the best of circumstances. Evaluating returns to IR&D is further complicated by the fact that contractors' IR&D programs and results remain their confidential property and thus unavailable for independent evaluation.

The GAO has done several major studies of IR&D since passage of P.L. 91-441, raising questions about whether IR&D is effective in meeting its stated objectives, whether it is cost effective, and whether other means of meeting its objectives might be preferable. Its most recent major analysis of IR&D was prepared for the Subcommittee on Research and Development of the Senate Armed Services Committee and the Subcommittee on Priorities and Economy in Government of the Joint Economic Committee.[44]

This GAO report looked at the relationship of IR&D projects to customer (DOD) requirements and examined contractors' planning and management of IR&D programs. It noted that discussions of IR&D benefits and outcomes have been largely anecdotal, based on descriptions of specific IR&D projects that yielded new technologies or advances in weapons systems capabilities. The GAO was unable to find any comprehensive, quantitative analysis relating all of any contractor's IR&D expenditures to specific developments.[45] Tracking IR&D costs and benefits is complicated by the time lags involved in translating research results into their technical realization; moreover, overlaps among technologies and projects blurs the distinctions between their specific inputs and outputs.

As part of the 1975 report, GAO conducted a pilot study to trace then-recent (i.e., 1972-1973) proposals and contract activity back to IR&D projects, and was able to establish many such relationships, although in some cases the contribution of IR&D was indirect. The pilot study also evaluated four contractors' IR&D programs over a 4-year period, looking at the firms' rationales for undertaking IR&D projects. Approximately 80 percent of the IR&D projects could be directly related to a known need or to an existing new product, while the remainder were projects for basic research, development of new concepts, or work that could lead to new business in the future.[46]

In the course of the 1975 study, GAO also reported on a special analysis by DOD of the role of IR&D-funded projects in the technolgies studied in DOD's Project Hindsight.[47]

Earlier industry and DOD reports on the effectiveness and benefits of IR&D were mainly anecdotal, featuring detailed case studies of specific projects and including descriptions of the "interconnections" between IR&D scientists and engineers working in industry and DOD personnel seeking to meet mission technical requirements.[48] The interconnections are characterized as a two-way network, providing feedback both to contractors and to DOD and balancing the guidance of DOD technical specialists, the initiative of scientists and engineers carrying out the IR&D, and the guidance of contractor management.

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[44] GAO, June 5, 1975.

[45] Ibid., p. 11.

[46] Ibid., p. 11-14.

[47] Ibid., p. 15.

[48] Tri-Association, 1974, p. 36-37, 51-246.

DOD spokesmen have repeatedly emphasized the appropriateness of IR&D and its benefits to DOD. For example, in 1982 testimony on IR&D before the House Appropriations Subcommittee on Defense, then-Under Secretary DeLauer stated that, ". . . IR&D and B&P is recognized by the DOD as a necessary cost of doing business, particularly in a high technology environment",[49] and that, "In summary, we believe company-sponsored research and development is an important national resource that provides benefits to DOD far beyond the cost included in our contracts." [50]

Critics of the IR&D process have countered these types of statements using as counterexamples cases of technical advances that resulted from direct contract work. Furthermore, they have argued that IR&D is simply a subsidy for large defense contractors and that DOD and industry claims for the qualitative benefits of IR&D cannot be substantiated quantitatively because of the scarcity of public information concerning the costs of IR&D programs, the nature of the work being performed, and the after-the-fact evaluations of this work by DOD.[51] These critics often contend that public funds could better be used to contract directly for needed R&D, rather than to reimburse IR&D costs.

One prominent critic, the late Admiral Hyman G. Rickover, testified in 1975 Senate hearings [52] that IR&D (and B&P) were "ill-founded and wasteful" programs that were not the most efficient use for scarce Government resources,[53] whose DOD controls were weak, and whose benefits were consistently overstated both by contractors and by Government officials.[54] Rickover stated that IR&D costs faced little downward competitive pressure, that DOD negotiators were in a weak bargaining position because of the concentrated nature of the defense industry, and that IR&D actually inhibited competition in the industry.[55]

Franklin Long and Judith Reppy of Cornell University testified at the same Senate hearings. They noted that DOD procedures for managing IR&D incorporated before-the-fact evaluations of contractors' proposed IR&D as well as after-the-fact evaluations of contractors' prior-year IR&D work. However, they found little publicly available information explicitly describing the linkages between these evaluations and the IR&D negotiation process.[56] Long and Reppy also considered the evidence for technical benefits from IR&D to be "incomplete and contradictory." [57] Based on their year-long study of IR&D, they demonstrated the difficulties and uncertainties to which independent evaluation of IR&D outside DOD are subject.[58] These can be summarized as:

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[49] House Appropriations Committee, Apr. 1982, p. 694.
[50] Ibid., p. 698.
[51] Reppy and Long, Jan. 1976.
[52] U.S. Senate, Sept. 1975, p. 687-702.
[53] Ibid., p. 688-689.
[54] Ibid., p. 690-693, 698.
[55] Ibid., p. 688-689, 692.
[56] Ibid., p. 706, 707, 717.
[57] Ibid., p. 723.

(i) the unavailability of firm figures for total IR&D/B&P expenditures,

(ii) the unavailability of complete lists of contractors that recover IR&D costs, and the amounts they receive,

(iii) the unavailability of comprehensive public descriptions of the technical work done under IR&D and B&P,

(iv) the difficulty in judging the depth and adequacy of DOD evaluations of IR&D proposals and the effectiveness of these evaluations or controls, and

(v) the scarcity of information on after-the-fact DOD analyses of specific benefits to the Government from IR&D expenditures.

Long and Reppy noted that better accountability, better evaluation, and assured relevance were essential modifications to the existing IR&D program, but suggested that DOD should explore alternative means to achieve the stated rationale and stated goals for IR&D. They preferred budgeted "level of effort" and exploratory R&D projects within DOD's RDT&E programs to IR&D.[59]

Admiral Rickover repeated his major criticisms of IR&D in testimony before the Joint Economic Committee on January 26, 1982. Noting that he considered the points he made in his 1975 testimony on the same subject still applicable, Rickover argued that IR&D was a waste of public funds and that the Government should purchase directly the research work it needs.[60] At the request of the Chairman of the Defense Subcommittee of the House Committee on Appropriations, the GAO conducted an assessment of Admiral Rickover's recommendations for improving DOD procurement including those concerning IR&D.[61] The GAO addressed three of Rickover's main points—that he considered IR&D a subsidy to large defense contractors, that he considered DOD's monitoring of IR&D superficial, and that the Government did not have sufficient control of, or rights to, work done under IR&D. GAO did not concur with the advisability of ending financial support for IR&D, but GAO did recommend that the Congress require DOD to (1) closely monitor Navy IR&D, (2) have an independent panel of experts eventually assess DOD's overall effectivness in monitoring IR&D, and (3) negotiate provisions giving the Government free use of IR&D results.[62]

In the fall of 1986, senior officials of both the Army and Navy raised the possibility of eliminating IR&D cost recovery on DOD contracts.[63] It was reported that this action was considered as a result of the fact that some contractors have refused to make technical data developed under IR&D available to the Services or to other potential contractors for the purpose of supporting competitive procurements on the grounds that such data was developed at private expense. The FY87 Defense Authorization Act (P.L. 99-661) supported the contractors' position. In reference to Section 953 of the Act, the conference report on the Act noted:

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[58] Ibid., p. 715. For a more complete treatment of their findings, see: Reppy, Judith V. The IR&D Program of the Department of Defense. Peace Studies Program Occasional Paper No. 6. Ithaca, N.Y., Cornell, U., Mar. 1976.

[59] U.S. Senate, Sept. 1975, p. 719.

[60] Statement of Admiral H. G. Rickover before the Senate Armed Services Committee and the Joint Economic Committee on IR&D, Sept. 29, 1975. Admiral Rickover asked that this statement be entered into the record of the January 26, 1982, hearing.

[61] U.S. General Accounting Office. Assessment of Admiral Rickover's Recommendations To Improve Defense Procurement. GAO/PLRD-83-37, Jan. 27, 1983.

[62] Ibid., p. ii–iii and 16–23.

[63] Army, Navy Seek to Limit Defense Dept. Funds for Independent Research. Inside the Administration. October 16, 1986. p. 5.

> Thus, reimbursement for Independent Research and Development expenses and other indirect costs (capital funds and profits), although such payments are in indirect support of a development effort, are treated for purposes of this Act as contractor funds.[64]

Army Undersecretary James Ambrose continued to advocate consideration of alternatives to IR&D, such as increasing the allowed rate of profit on cost-type contracts, in the context of reconsideration of a range of incentives to contractors embodied in the Federal Acquisition Regulations.[65] However, it is reported that he has recently decided not to pursue this direction because it ". . . would require a wholesale revision to the way the government does business with contractors."[66]

In summary, efforts to measure or evaluate the outcomes from expenditures on IR&D have consistently met with little success because of: (1) fundamental methodological and econometric problems inherent in assessing the outcomes of research and development generally, (2) the fact that total funding *inputs* to IR&D are indeterminate due to the way in which records are kept and disseminated, and (3) the lack of systematic and comprehensive evaluations of specific IR&D project results by DOD. It is unlikely that all of these barriers to evaluation can be completely overcome, regardless of any determination to do so, although the Rand study referred to earlier may provide greater understanding than is now available.

## E. CONTRASTS BETWEEN IR&D AND OTHER MEANS OF R&D SUPPORT

One way to assess the efficiency, effectiveness and other outcomes of IR&D is to compare its costs, benefits and distributional consequences with alternative mechanisms of support, or with possible modifications of the existing system. The most frequently mentioned alternative to IR&D is to increase direct support of defense-related R&D through industrial contracts, and this section focuses on some of the considerations in adopting this approach. Other possible alternatives include eliminating the IR&D mechanism and/or performing more defense-related R&D in DOD laboratories. Less sweeping changes have also been suggested. The current system might be modified, for example, by replacing negotiated IR&D overhead rates with a fixed rate, by requiring open publication of all IR&D results, by requiring external prospective peer review of IR&D brochures, by establishing formal technology transfer programs for communicating IR&D results among DOD contractors, or by relaxing the requirement for potential military relevance for IR&D.

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[64] U.S. Congress. House. 99th Congress, Second Session. National Defense Authorization Act for Fiscal Year 1987. Conference Report to Accompany S. 2638. October 14, 1986. p. 511.

[65] Inside the Administration. Top Army Official Says Higher Profits, Overhead Cost Relief Can Replace IR&D. November 27, 1986. p. 9.

[66] Army Drops Push to Require Contractors to Foot Bill For Certain R&D Costs. Inside the Administration. February 19, 1987. p. 7.

A complete analysis of these alternatives to IR&D—whose adoption could have far-reaching consequences, both positive and negative—is beyond the scope of this chapter. In particular, no attempt is made here to reexamine the current policy that it is in the national interest to encourage private industry to perform research to help ensure the continued development of new military technologies. Instead, this section addresses the more narrow question of designing the best method for achieving this goal. The subsequent section addresses possible extensions of mechanisms like IR&D to support civilian R&D.

Evaluating the returns to *any* form of R&D support is fraught with difficulties, as is any *a priori* attempt to compare probable outcomes from alternative forms of R&D support. In the case of IR&D, problems of evaluation are confounded by the lack of public visibility into the IR&D process and by the fact that the work for which IR&D costs are reimbursed is treated as company proprietary. Nevertheless, it is helpful to contrast some aspects of the IR&D mechanism with strawman alternatives—namely, (1) no special DOD incentives for industry to perform defense-related R&D (other than the obvious benefits to the contractor from successfully competing for DOD R&D and procurement contracts), and (2) increasing the use of contracts to procure longer-term, defense-related R&D.

As noted previously, the IR&D method of supporting contractors' in-house R&D by allowing them partial cost recovery through overhead on Government contracts is intended to maintain the base of technically competent contractors, encourage long-term research, promote technical diversity and competition, and shorten the lead time for contractors to respond to DOD requests for proposals for advanced technology. Using IR&D, DOD seeks to accomplish these goals by establishing a system wherein a "competition of ideas" occurs in-house as each contractor's R&D staff compete for inclusion of their projects in the firm's IR&D portfolio and, thus, for partial cost recovery through the IR&D mechanism. The intended result of this *intra-contractor* competition for R&D project funding is enhanced technological and cost competition in the *inter-contractor* market for Government procurement contracts. Critics have variously argued, on the other hand, that the current system encourages unnecessary duplication and waste, that it fails to deliver new defense technologies in proportion to its costs, that there is insufficient oversight and administration, that it inhibits competition in the already concentrated defense procurement market, and that it contributes to the acceleration of the arms race.

By contrast to the IR&D approach, if DOD offered no special incentives for defense-related R&D, and if current and potential DOD contractors based their R&D portfolio decisions solely on expected returns from future contracts and sales, then the base of technically competent contractors willing to compete for DOD business might shrink as firms oriented their in-house R&D programs toward less risky or potentially more profitable areas. Alternatively, if DOD replaced the IR&D mechanism by awarding special contracts for long-term R&D, the outcome of the review of competitive proposals by DOD reviewers could be a narrowing of the range of R&D actually being performed. The long-term consequences of this approach could be reductions in the diversity and flexibility of the DOD technological base. While this approach could reduce duplication of IR&D efforts and thus reduce costs and waste in the short run, it might also narrow the population of contractors with competence in each technical area. In the long run, it is not clear whether this approach would result in more, or less efficient and effective utilization of the Nation's R&D resources.

The process by which a contractor prepares and submits an IR&D "brochure" to DOD and receives feedback on its contents may result in greater technical communication between the contractor and DOD technical managers than might happen in the course of regular RDT&E contracts. Such communication benefits both DOD and the contractors by enhancing each side's awareness of new research findings, of promising areas of research, of mission requirements, and of company capabilities. Examples of the role of IR&D in enchancing technology transfer and the dissemination of scientific and technical information are given in the Tri-Association report.[67] If IR&D were eliminated, alternative mechanisms to replace its information transfer aspects would be desirable and might function at lower cost but be more difficult to structure.

Certain features of the existing IR&D system contrast interestingly with both contract R&D and conventional product markets. These features affect (1) the sharing and shifting of technological and financial risks and benefits, and (2) who must demonstrate technical success and when. In a commercial product market, a producer invests in developing and producing a new product and bears the risk that he will not recoup these costs if future product sales are disappointing. By contrast, a contractor who conducts IR&D bears some additional, relatively small, costs of negotiating agreements with, and providing requisite technical data to, the Government. But, once his brochure is accepted, he stands to recoup a substantial fraction (typically about 36 percent) of his ongoing IR&D costs from current contracts rather than from hypothetical future sales. Also, the informational aspects of the IR&D technical review improve the contractor's understanding of current and future DOD mission requirements. A contractor who performs contract R&D pursuant to a well-defined Government request for proposals faces even lower technological and financial uncertainties.

The potential private benefits to be gained also differ for the cases described above. Consider three situations. First, a firm producing for a commercial market faces the highest degree of market uncertainty and puts its own funds at risk when it does R&D related to a new product. However, it also typically enjoys the greatest financial gain from projects that are successful. By contrast, a firm performing DOD contract R&D does not risk its own funds on such projects, but its profits are limited to the contract fee, and it does not receive exclusive rights to use the results. Therefore, while its risk is lower, it does not stand to gain as much advantage over competitors as if it held title to the R&D results.[68] The third situation is a defense contractor that can recover a portion of its IR&D costs as overhead on Government procurement contracts while retaining the rights to its IR&D results. It may, therefore, realize greater gains than if the work were done under direct contract: the IR&D results might lead to new Government contracts as well as to new commercial products. However, the more militarily-relevant is the contractors portfolio of IR&D, the more limited is the potential for spin off to other customers.

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[67] Tri-Association 1974, p. 34-37.

Under IR&D, the decision to reimburse a contractor for a portion of his IR&D costs is made before the work is performed and the results are known. In the short run, this may lower the apparent "productivity" of IR&D money to the Government, because some contractors' IR&D projects may appear *in retrospect* to be unnecessarily duplicative, to lack immediate applicability, or to be technical "failures." However, in the long run, the realized productivity of IR&D may be much higher than a short-run view would indicate. Part of the gain from IR&D is educational, as the contractor develops expertise in new areas through the accumulated experience of in-house researchers. This may serve to enhance inter-contractor competition in the long run. Alternative approaches intended to enhance the short-run productivity of R&D funding, based on *a priori* demonstration of success, might not necessarily improve long-run productivity, especially if R&D projects having greater technical risk were curtailed. The continuing expressions of DOD satisfaction with IR&D often refer to the greater diversity of the portfolios of contractors' IR&D work, compared with DOD-directed R&D projects.[69] To the extent that contractors' IR&D efforts provide a broader range of information that helps to improve competition for procurement contracts and reduce the technical risks in system selection and acquisition (the most expensive portion of the DOD procurement budget), IR&D can offer substantial long-term benefits to DOD and the public.

The IR&D mechanism has been used to benefit other types of R&D performers. For example, a 1982 DOD IR&D Policy Council initiative sought to strengthen the universities' research capabilities in science and engineering, to contribute to the training of science and engineering students, and to promote the transfer of university research results to new applications by using evidence of industrial contractor support of universities as one criterion for judging the level of IR&D cost recovery. According to DOD, while IR&D-performing contractors were found to be extensively involved in cooperative R&D programs with universities, they were generally opposed to a requirement for an additional, separate formal submission of documents demonstrating the extent of their efforts to DOD because of the resources required to gather the necessary data. Contractors were not opposed to informal reporting, according to DOD.[70]

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[68] This disadvantage may be somewhat ameliorated for defense contractors because of the relatively concentrated nature of the defense industries and the relatively infrequent entry of new firms as major defense contractors.

[69] See, for example: GAO June 5, 1975, p. 51; Testimony of R. DeLauer in House Appropriations Committee, Apr. 1982, p. 695.

The requirement that IR&D work must demonstrate potential military relevance ("PMR") in order for any of the associated costs to be reimbursed may constrain the scope of in-house R&D that a contractor is willing to undertake. In particular, difficulties in demonstrating PMR for basic research, combined with the availability of current-year cost recovery for applied work, which is clearly eligible for cost reimbursement, may bias a DOD contractor's in-house R&D toward more applied or "relevant" areas and away from more fundamental or frontier work that is more risky but that could have important long-term benefits not only for defense but for society at large.[71] Also, IR&D may serve as a barrier to exit from defense markets by discouraging contractors from diverting scarce technical resources away from defense technologies and towards otherwise-attractive technologies that might enhance civilian industrial competitiveness. Therefore, any reexamination of the costs, benefits and outcomes of IR&D, as well as of alternative mechanisms to support research in defense-related or dual-use fields, may find it advisable to take long-run, as well as short-run, considerations into account and may wish to examine the implications of these support mechanisms for the Nation's R&D infrastructure as a whole, rather than considering the defense sector in isolation.

## F. CURRENT AND POTENTIAL USES OF THE IR&D MECHANISM IN CIVILIAN R&D

Previous sections of this chapter have discussed use by the Department of Defense of the Independent Research and Development mechanism to support a portion of its contractors' research and development projects via overhead allowances on procurement contracts. As detailed earlier, this program has been controversial, in part due to disagreement over the relative merits of accountability and flexibility. At the expense of a loss of oversight of part of the contractors' R&D programs, and of a reduction in accountability to Congress for the overhead funds that support it, the IR&D mechanism is said to encourage a greater diversity of technical effort, to enhance competition in technology-based procurement contracts, and to make the overall system of defense R&D more flexible and adaptable to changing circumstances than could be achieved through reliance solely on direct contracting for R&D. Equivalent to about 7% of DOD's RDT&E budget, IR&D is an adjunct to DOD's mainstream research and development activity.

This section examines the history of, and potential for greater use in the future of, the IR&D approach to Federal funding of R&D in the *civilian* sector, both in industry and in the universities.

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[70] Paris Genalis, DOD Office of Research and Laboratory Management, personal communication, March 18, 1987. For a review of industry response to this initiative, see Leo Young, The IR&D Initiative on Industry-University Interactions, Office of the Deputy Undersecretary of Defense for Research and Advanced Technology, October 1986, 22 pages.

[71] This point was made by R. DeLauer, former USDRE, in testimony before the Science Policy Task Force of the House Science and Technology Committee on Oct. 2, 1985. The 1975 DSB report had recommended that, if future changes in the IR&D/B&P process were considered, the PMR requirement be broadened to ensure that the relevance tests not be limited by particular technical interests of the DOD reviewers and also that DOD support a test of "potential *Government* relevance [emphasis added]. (DSB, March 1975, p. ix–x.)

First, current and past uses of the IR&D mechanism by such civilian agencies as NASA, the Atomic Energy Commission, and the Federal Aviation Administration are reviewed. Subsequently, the idea of extending the IR&D concept to Federal support of university research is presented and analyzed, including consideration of its implications for the determination of allowable costs of university research and development under OMB Circular A-21 ("Cost Principles for Educational Institutions").

### 1. IR&D IN CIVILIAN AGENCIES: NASA, AEC, AND FAA

Certain civilian agencies, most notably NASA, have also allowed their contractors to recover some of their IR&D (and B&P) costs through overhead on procurement contracts. NASA and the FAA currently allow IR&D cost recovery on some contracts; the AEC (and, subsequently, the Energy Research and Development Administration, ERDA) did allow IR&D cost recovery, although their successor agency, the Department of Energy, does not.[72]

#### *a. National Aeronautics and Space Administration*

NASA's stated rationales for IR&D have been similar to those of DOD in accepting IR&D (and B&P) costs as necessary costs of doing business and in affirming that R&D done under IR&D has been "a major contributing factor to maintaining a strong and creative technological and industrial capability . . . of utmost importance to the success of NASA's mission." [73]

Historically, NASA policies and procedures for IR&D/B&P have followed closely those of DOD; the current Federal Acquisition Regulations principles apply to both agencies, as did those in the earlier Armed Services Procurement Regulations. The DOD Tri-Service Negotiators (TSN's) conduct the services' IR&D negotiations with inputs from NASA; agreements or formulas determined by the TSN's also apply to NASA's cost-based contracts (as well as to those of other agencies).[74]

According to the 1975 GAO study, NASA views the joint DOD-NASA control of IR&D as beneficial because it reduces NASA's administrative costs and burdens.[75] However, unlike DOD, NASA is under no legislated obligation to determine that the IR&D it reimburses funds projects with potential military relevance. Some observers have suggested that NASA's interests could be harmed to the extent that contractors slant their in-house R&D toward DOD interests or that DOD negotiators reject IR&D projects that are valuable to NASA but lack military relevancy.[76]

Table V shows contractors' IR&D, B&P, and OTE costs recovered from NASA contracts for the period FY1963-73, and Table VI shows NASA IR&D and B&P data for calendar years 1974-1984. Note that NASA's payments have been much smaller than

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[72] For a description of the NASA and AEC IR&D and B&P policies, see, GAO, June 5, 1975; U.S. GAO, Allowances for Independent Research and Development Costs in Negotiated Contracts—Issues and Alternatives. February 16, 1970, (Hereinafter referred to as GAO, Feb. 16, 1970.)

[73] GAO, June 5, 1975. p. 71.

[74] See NRC, March 1981, p. 20.

[75] Ibid., p. 72.

[76] Ibid. See also NRC, March 1981, p. 34-35.

DOD's—NASA's IR&D/B&P payments peaked in the late 1960s (during the Apollo program) when they were equivalent to some 30 percent of the amounts paid by DOD. As the Space Shuttle program began in the early 1970s, NASA's IR&D and B&P payments declined sharply. By the mid-1970s, NASA's payments for contractors' IR&D/B&P were equivalent to only 10 to 15 percent of DOD's payments, and were typically three to five percent of contractors' sales to NASA. Table VI shows that, although sales to NASA increased dramatically as the Shuttle program matured, IR&D and B&P payments declined slightly as a percentage of sales, averaging just under three percent in the early 1980s.

Table V

Statistics Related to NASA IR&D and B&P, 1963-1973
(Millions of dollars)

| Fiscal Year | Payments to Contractors | | | | | Total as % Sales to NASA |
|---|---|---|---|---|---|---|
| | IR&D | B&P | IR&D+B&P | OTE | Total | |
| 1963 | 24 | 23 | 47 | 10 | 57 | na |
| 1964 | 50 | 43 | 93 | 28 | 121 | na |
| 1965 | 60 | 55 | 155 | 17 | 131 | na |
| 1966 | 69 | 68 | 137 | 17 | 154 | 3.4 |
| 1967 | 58 | 50 | 108 | 16 | 124 | 3.3 |
| 1968 | 61 | 46 | 107 | 14 | 121 | 3.7 |
| 1969 | 43 | 49 | 92 | 15 | 107 | 4.1 |
| 1970 | 44 | 48 | 92 | 9 | 101 | 4.7 |
| 1971 | 41 | 51 | 92 | 7 | 99 | 5.0 |
| 1972 | 40 | 50 | 90 | 0 | 90 | 4.5 |
| 1973 | 40 | 47 | 85 | 0 | 85 | 4.8 |

Source: Information from NASA reported in Judith V. Reppy, Cornell University Peace Studies Program. Occasional Paper #6. March 1976. p.61.

Table VI

Statistics Related to NASA IR&D and B&P, 1974-1985
(Millions of dollars)

| Calendar Year | Payments to Contractors | | | Contractor Sales to NASA | Total as % Sales to NASA |
|---|---|---|---|---|---|
| | IR&D | B&P | Total | | |
| 1974 | 39.0 | 39.4 | 78.4 | 2,007 | 3.9% |
| 1975 | 40.3 | 38.2 | 78.5 | 2,277 | 3.5 |
| 1976 | 41.3 | 41.1 | 82.4 | 2,419 | 3.4 |
| 1977 | 45.5 | 42.9 | 88.4 | 2,547 | 3.5 |
| 1978 | 48.8 | 40.5 | 89.3 | 2,699 | 3.3 |
| 1979 | 54.7 | 43.3 | 98.0 | 2,996 | 3.2 |
| 1980 | 56.6 | 45.2 | 101.8 | 3,643 | 2.8 |
| 1981 | 65.7 | 49.4 | 115.1 | 4,174 | 2.8 |
| 1982 | 66.8 | 51.8 | 118.6 | 4,243 | 2.8 |
| 1983 | 77.7 | 55.9 | 133.6 | 4,553 | 2.9 |
| 1984 | 85.8 | 67.3 | 153.1 | 5,526 | 2.8 |
| 1985 | 89.8 | 71.1 | 160.9 | 6,006 | 2.7 |

Source: Defense Contract Audit Agency as provided by NASA.

### *b. Atomic Energy Commission (Department of Energy)*

The AEC's policies for IR&D (and B&P) differed from the DOD-NASA model, in large part because of differences in the agencies' procurement activities and contractor bases.[77] The GAO studies of IR&D found that approximately 80 percent of the AEC's procurement contracts were with firms that operated AEC-owned plants and equipment on a cost-plus-fixed-fee basis, with no financial risk for the contractor.[78] These contractors did not finance independent R&D; instead, the AEC fully funded the R&D it considered "necessary." [79] The remaining 20 percent of AEC's procurement contract volume was with contractors that used privately-owned facilities (and often contracted with DOD or NASA, as well). These contractors, as well as industrial subcontractors performing work in their own facilities, could recover some of their IR&D costs from the AEC.

According to the GAO, the AEC accepted a limited portion of IR&D costs incurred by contractors performing AEC work in their own facilities without advances of Government funds. However, the AEC criteria for reimbursement were more restrictive than those of DOD and NASA: the IR&D could not duplicate any AEC-sponsored IR&D, and it had to directly or indirectly benefit the AEC contract work. Also, IR&D that was primarily promotional or even partially supported by another sponsor was ineligible for reimbursement.[80]

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[77] See GAO, June 5, 1975, p. 72-77, and GAO, February 16, 1970, p. 17-20 for a comparison of the AEC and DOD-NASA policies.

[78] Ibid.

[79] According to the 1975 GAO study, the AEC based its rationale concerning IR&D on the fact that, unlike DOD or NASA, it did not rely heavily on private industry and privately-owned R&D facilities. Instead, its procurement was heavily concentrated in a technical field where the Government had developed most of the technology. Thus, IR&D was not seen as a desirable mechanism for innovative R&D, and the AEC used practices other than IR&D to develop a competitive, private nuclear industry. GAO June 5, 1975, p. 73-74.

The AEC acquired rights to technical data and inventions developed under IR&D it reimbursed. These rights were pro-rated based on AEC's share of total project costs, if this share exceeded 20 percent.[81] In 1972, 1973, and 1974, the AEC allowed $1.9 million, $1.4 million, and $1.6 million respectively, or less than five percent of the approximately $40 million of NASA reimbursements for IR&D in those years.[82]

When ERDA was established, it assumed AEC's responsibilities and issued a temporary regulation on July 29, 1975, allowing IR&D reimbursements.[83] ERDA subsequently discontinued allowances for IR&D, and the DOE does not allow IR&D at present.[84]

### c. *Federal Aviation Administration*

The FAA does business with some of the same contractors that negotiate IR&D/B&P agreements with DOD; typically, these contractors supply equipment for radar systems, aircraft navigation, and air traffic control. Using the same procedures as stated in the FAR for DOD, the TSN's do the actual negotiations. They include FAA business in the pool of "Government business" used to set IR&D overhead rates, and the FAA picks up its allocable share as overhead on FAA cost-based contracts. FAA payments for IR&D are not tracked or reported by the DCAA, and exact figures are not available. FAA sources estimate that the total for IR&D/B&P amounts to perhaps 0.5 percent of sales to the agency.[85] Like NASA, the FAA has no relevancy requirement for the IR&D it reimburses. In some instances, small contractors that have no sales to DOD negotiate directly with the FAA for IR&D cost recovery. In these cases, the FAA follows the FAR formulae to set a base and ceiling for reimbursements.

## 2. IR&D IN FEDERALLY SUPPORTED UNIVERSITY RESEARCH

### *a. IR&D Reimbursements to Universities: the Major Issues*

Just as Federal reimbursement for a portion of contractors' IR&D costs is sometimes seen as an effective way to help these Federal suppliers explore new and emerging technical areas that may put them in a better position to respond to future DOD procurement needs, it has been argued with increasing intensity that the Federal government also has a responsibility to assist the research universities, another group of key performers of Federally-sponsored research, to strengthen their capacities to respond to governmental and societal needs for research.

Universities, and their supporters, have argued that the existing system of Federal project grants and contracts for research fails to compensate them for certain of the costs of doing research that they must therefore meet from other, limited sources of income, such as student tuition, endowment income, and unrestricted gifts. These unmet costs may include portions of the costs of the purchase of major instrumentation, maintenance and servicing of specialized equipment and facilities, recruiting new faculty, assisting existing faculty to develop new areas of expertise as old areas are exhausted or new opportunities arise, and maintaining research professional and support staff for short periods of time between Federal grants or contracts. Sometimes this issue is framed in terms of a Federal responsibility to support a portion of the costs of maintaining the "infrastructure" [86] of university research.

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[80] Ibid. p. 73-77. B&P costs had to be directly applicable to AEC programs and excluded promotional or selling costs.

[81] Ibid. p. 75. In practice, the AEC share seldom exceeded 20 percent, so few rights were transfered to the Government.

[82] U.S. Senate, Sept. 1975. p. 129.

[83] Ibid.

[84] Department of Energy, personal communication. July 23, 1985.

[85] Federal Aviation Administration, personal communication, January 31, 1986.

There is relatively little opposition to Federal funding of university infrastructure on principle. Rather, the question goes to differences in priorities for Federal funding; that is, to whether there is room in the budget for such spending. Furthermore, there are different views about the most effective strategy for allocating whatever funds might be available. It is beyond the scope of this report to review or analyze all of the proposals that have been made in recent years for addressing the problems of university infrastructure.[87] This section addresses primarily the use of the Independent Research and Development mechanism as one approach to Federal financing of a portion of the cost of maintaining the university research infrastructure.

### *b. Proposed 1981 Modification of OMB Circular A-21 to Include IR&D*

Several proposals have been considered in the past to allow universities to charge costs analogous to IR&D on their Federal research contracts and/or grants.[88] In 1978, the Office of Management and Budget (OMB) proposed certain modifications to its Circular A-21.[89] While the OMB proposal did not involve changes that would permit universities to recovery IR&D-like costs on Federal R&D contracts, at least one major organization of the research universities, the Committee on Governmental Relations (COGR) of the National Association of College and University Business Officers (NACUBO), proposed in response to the draft that IR&D costs be recoverable by universities as a supplement to the costs of all Federal research and development grants and contracts. To support its proposal the Association said:

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[86] In this section, "infrastructure" refers to all of these elements, not just to facilities and equipment.

[87] See, for example, the following recent reports. "Bricks and Mortar: A Summary and Analysis of Proposals to Meet Research Facilities Needs on College Campuses", Congressional Research Report prepared at the request of the House Committee on Science, Space, and Technology; Subcommittee on Science, Research and Technology, prepared by Michael E. Davey, Edith Fairman Cooper, and Christine Matthews Rose, April 13, 1987; Office of Science and Technology Policy, Executive Office of the President, "Report of the White House Science Council Panel on the Health of U.S. Colleges and Universities", February 1986 (hereinafter, White House Science Council, 1986); National Science Board, Office of Science and Technology Policy, and Government-University-Industry Research Roundtable, "Academic Research Facilities", Report of a Conference, 1986 (hereinafter, NSF-OSTP-GUIR Report, 1986); and United States General Accounting Office, Report to the Chairman of the Committee on Science and Technology, U.S. House of Representative, "University Funding: Assessing Federal Funding Mechanisms for University Research, Report GAO/RCED-86-75, February 1986.

[88] Neither the Department of Defense nor the other contracting agencies allow universities to recover IR&D or B&P as elements of overhead expenses on grants or contracts.

[89] United States Office of Management and Budget, Executive Office of the President, Circular A-21, Cost Principles for Educational Institutions, undated.

> Adoption of this proposal will significantly strengthen the research capacity of the nation by providing support for university independent research and development programs to meet government needs, will minimize the loss of research capacity resulting from interruption in the funding of ongoing programs and will stimulate the early development of junior research faculty who represent a major source for the successful conduct of research programs in the future.[90]

NACUBO proposed that certain expenses of educational institutions ". . . for the purpose of maintaining or improving research capability . . ." be chargeable as a direct cost category on each of the institution's sponsored research projects. While this brief statement of NACUBO's proposal is unclear on the matter, it would appear that such allowable expenses, up to a limit of five percent of the direct costs of "organized research"[91] each year, would be burdened by the usual indirect cost rate for the university, and the total would be apportioned to grants and contracts as a category of direct cost. It is unclear whether NACUBO intended that these "IR&D" direct costs be burdened a second time at the indirect cost rate applying to the projects to which they were to be added.

OMB did not include the proposal with respect to IR&D in the revision of A-21 it issued in 1979. However, it did establish an interagency task force involving research-funding and administrative agencies of the Federal government to study the proposal and to make a recommendation to OMB on it. The Task Force examined the matter during 1980, and on January 2, 1981, OMB proposed in a Federal Register Notice to include IR&D as a new category of allowable indirect cost for universities. Specifically, the proposal was to add a new paragraph, J.45, as follows:

> Independent Research and Development Costs
>
> a. The costs of independent research and development are those incurred by the institution for the purpose of maintaining or improving research capability and effectiveness. They include salaries and other costs for projects that have been approved by the institution to meet the purposes of independent research and development as specified in an institutional plan. Costs of independent research and development are allowable, but are limited to 1% of the modified total direct costs of sponsored research in the current accounting period.
>
> b. The costs in this category shall be treated as indirect costs and allocated currently to all activities of the institution.[92]

This proposal, while going a long way toward establishing the concept of a Federal role in sustaining the research capacity, or

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[90] National Association of College and University Business Officers, "Response to Revision Proposed by Office of Management and Budget on March 10. 1978", Washington, D.C., June 5, 1978, pages 40 and 41.

[91] "Organized research" is defined in A-21 as ". . . all research and development activities of an institution that are separately budgeted and accounted for."

[92] Federal Register, Vol. 46, No. 1, Friday, January 2, 1981, p. 183.

"infrastructure," of the research universities, was substantially more modest than the universities themselves had proposed in late 1980. Four major organizations jointly proposed that OMB include a limit, not of one percent, but of five percent of the direct costs of sponsored research, with a proposed ceiling of three million dollars per year for any one institution.[93] Furthermore, they proposed that the allowable IR&D costs be treated as a direct cost category and that they be further burdened with the indirect cost rate for the institution as if they were an element of direct cost. Since the overhead, or indirect cost, rate for universities is typically around 40 percent of modified total direct costs, adding the overhead would raise the actual IR&D recovery rate from five to approximately seven percent of the direct costs of sponsored research at the average university under this proposal.

There was opposition to the proposed changes in A-21 from the National Science Board and lack of support, although not outright opposition, from the American Association of Medical Colleges.[94] OMB withdrew the proposal in early 1982, saying, "A proposal pertaining to allowability of independent research and development costs received a mixed reception and no changes in that area are proposed here." [95]

Other proposals were advanced to fund university research capacity around the same time as the OMB proposal. In 1980, the privately-organized, "blue-ribbon" National Commission on Research (NCR) recommended that the Government and the universities work together to develop or adapt a new funding mechanism which it labled "research capacity support." [96] Research capacity support funds would be used to pay for smoothing voids and discontinuities in Federal project funds, to meet emergencies and unexpected opportunities, to update facilities, to launch new investigators' research programs, and to develop and maintain shared research resources.

The funds for the mechanism proposed by the Commission would come principally from the Federal government, in amounts proportional to the total level of Federal support of R&D at each institute. The Commission suggested an amount in the range of one to three percent of current funds. Universities would provide an additional 10 percent of the Federal contribution from their own funds. The Commission noted that making the amount of such award proportional to other Federal R&D funds would ". . . provide[s] a tie to the existing quality assurances and selection processes and a connection between need and response." Research capacity support funds would be allocated by the recipient institution consistent with certain general principals established by the Government in consultation with the research universities. The Commission recognized that Federal funds for this purpose would be diverted from existing Federal R&D budgets and would not be an add-on.

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[93] The organizations were the American Council on Education, the Association of American Universities, the National Association of State Universities and Land Grant Colleges, and the National Association of Independent Colleges and Universities.

[94] Milton Goldberg, Council on Governmental Relations, personal communication, January 30, 1986.

[95] Federal Register, 47:4, 932, January 7, 1982.

[96] National Commission on Research, Funding Mechanisms: Balancing Objectives and Resources in University Research, May 1980, page 31.

The mechanics of the proposals by NACUBO and NCR would be substantially different from the mechanics of DOD's support of IR&D. Setting the question of mechanics aside, however, what is of interest to this discussion is the notion underlying these proposals that universities incur costs of R&D that are not currently recoverable under the system of project grants and contracts for support of R&D, and that the Federal government has a responsibility to help pay for them.[97]

No formal estimates appear to have been made of the aggregate costs of allocating IR&D-like funds in this manner to Federal R&D contracts and grants to universities. A rough estimate of the cost of the universities' 1980 proposal to charge IR&D of five percent, plus overhead, can be obtained as follows. Suppose that the proposal had been in place in FY1984 and that Federal support of R&D in universities, exclusive of IR&D, would have remained the same. In that year, the Federal government obligated approximately $5.57 billion to universities for R&D, exclusive of contracts for FFRDC's (Federally-Financed Research and Development Centers) administered by universities.[98] While no definitive estimates are available on the proportions of Federal R&D spending in universities that pay for direct and indirect costs, data reported in a recent paper by Thomas and Lederman [99] suggests that approximately 70 percent pays for direct costs, and the remainder for indirect costs. Thus, in 1984, the direct costs amounted to approximately $3.9 billion and the indirect costs to about $1.67 billion. If the proposal to add five percent of the direct costs, plus ordinary overhead, to the budget of each grant and contract had been in place, approximately $200 million of additional direct costs and $86 million in indirect costs would have been reimbursed to universities as "IR&D". In toto, the universities' proposal would have increased Federal obligations to universities for support of R&D in FY84 by about $286 million.

The recommendation of the National Commission on Research was more modest. Using a figure of two percent of current Federal funding as the basis for the size of the "research capacity support" funds, NCR's proposal would have allocated about $111 million of *existing* Federal R&D support to universities to this purpose in FY1984. Thus, the NCR proposal would have caused no additional costs to the Government as proposed. Universities would have contributed 10 percent of this amount from their discretionary funds, or about $11 million.

OMB's proposed revision of Circular A-21, which would have allowed for recovery of IR&D up to one percent of direct costs, would have cost about $39 million at the maximum. The recent White House Science Council report does not offer specific quantitative suggestions for university research funding levels. However, the report does say:

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[97] For a more recent expression of this concern by a high-level body, see for example, the report by the White House Science Council, 1986, op cit.

[98] National Science Foundation. Federal Funds for Research and Development: fiscal years 1983, 1984 and 1985. NSF Report 84-336, page 28.

[99] Thomas, Eleanor C. and Leonard L. Lederman. Indirect Costs of Federally Funded Academic Research. National Science Foundation, Division of Policy Research and Analysis, August 3, 1984, manuscript.

> The federal government [should] make substantially greater investments in our centers of learning in the 1980's and 1990's than in the 1970's. The recommendations set forth in this report, if they are to be implemented fully, require significant increases in financial support. The source of such funding in these times of stringency is not obvious. Reallocation of R&D appropriations appears to be the most probable source, but we believe that incremental new funding will be required. In any case, we emphasize that this federal investment, at a minimum, must keep pace with the overall national investment in R&D; at the current rate of growth it will double in ten years.[100]

### c. *Current Status of IR&D Under OMB Circular A-21*

OMB Circular A-21 currently does not include IR&D as a category of recoverable costs on university grants and contracts. However, in considering the possible use of the IR&D mechanism for universities, several aspects of A-21 should be examined.

First, A-21 allows for recovery of "Proposal Costs" under Section J-28, page 36, of Part J, "General Provisions for Selected Items of Cost." A-21 defines "proposal costs" as:

> . . . the costs of preparing bids or proposals on potential Government and nongovernment sponsored agreements or projects, including the institution's bids or proposals. Proposal costs . . . normally should be treated as indirect costs and allocated currently to all activities of the institution. . . .

Furthermore, A-21 also notes on page 20 that:

> Failure to mention a particular item of cost is not intended to imply that it is either allowable or unallowable; rather determination as to allowability in each case should be based on the treatment provided for similar or related items of cost.

The first-quoted provision of A-21 appears to allow for recovery of bid and proposal (B&P) costs on Federal grants and contracts to universities, following a cost-allocation arrangement between Federal and non-Federal projects similar to that used in the DOD IR&D and B&P mechanisms. As noted below, both the Department of Health and Human Services and the Department of Defense, the two auditing agencies for university R&D, currently permit recovery of certain allocable B&P costs by universities.

The second provision of A-21 quoted above might appear to establish a basis for a claim of recoverability of IR&D costs, based on their treatment in another context (DOD support of IR&D in industry), where B&P and IR&D are treated as similar, and indeed interchangeable in practice. However, in fact, neither HHS nor DOD allows recovery of IR&D costs on university R&D grants and contracts.

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[100] White House Science Council, 1986. p. 5.

According to the Department of Health and Human Services, IR&D expenses of universities are included under the category, "Departmental Research", and are thus not allowed as recoverable under Federal grants and contracts for R&D.[101] Circular A-21 defines departmental research as "all research and development activities that are not organized research and, consequently, are not separately budgeted and accounted for." (According to this interpretation, if universities were to create specific budget accounts under which to finance and account for IR&D costs, these expenditures might then be classified as "organized research". It is not known whether HHS or DOD would regard such costs as recoverable if universities adopted this practice.)

### *d. Other Approaches to Federal Support of University Research Capacity*

The cost categorization and definitions contained in Circular A-21 are not the central issues in determining whether IR&D costs might be recoverable by universities. The real question is a policy matter: should the Federal government accept the responsibility for compensating universities for some fraction of the costs of R&D listed earlier that contribute to the maintenance of the university's research infrastructure and capacity? If the answer is "yes", Circular A-21 could be modified where necessary as one approach to achieving this goal. If it is determined that the Federal government has no such broad responsibility, then Circular A-21 need not be addressed.

Other approaches might be considered for supporting the universities' research capacity that might have the same effect as overhead-based IR&D, without some of its complications. For example, universities might be awarded block grants in proportion to the amount of their current competitive awards. These grants could be used to support such activities as junior faculty research, explorations of new and highly risky research areas, and bridging of support between grants and contracts for graduate research assistants and professional non-faculty staff. If such block grants were awarded by each Federal R&D funding agency in proportion to its level of grant and contract support, they might accomplish the same purposes as an IR&D-like mechanism without the difficulties inherent in administering IR&D.

On the other hand, if accountability for expenditures of such block grant money is of primary concern, mechanisms would have to be established for peer and/or agency review of activities under the block grant, perhaps on a post-hoc basis. As discussed in previous sections, DOD requires contractors to define specific R&D projects and to demonstrate both their quality and potential military relevance in order to qualify for IR&D cost recovery. Furthermore, evaluation of IR&D brochures requires presentation of the results of previous IR&D projects to DOD technical evaluation teams, both to ensure quality and to enhance the transfer of the results to the sponsoring agency. In the case of university research, the quality of the research is enforced via peer review of results before publication and by evaluation of the performance of faculty based heavily on that publication. The transfer of university research results to the Federal sponsor is typically not of primary concern, since publication of results in the open literature is the major mechanism of information dissemination and "technology transfer" for most university research. To reinforce these practices, block grants to universities for "IR&D" might include a requirement that results of successful projects be submitted for publication in the open literature, although publication could generally be expected without such a requirement since it is standard university practice. Unlike DOD's IR&D activity, university research expenditures under such block grants would not be required to be relevant to the sponsoring agencies' missions, since the funds would be targeted on the support of new and high risk ventures more akin to basic research. In fact, a mission relevance requirement might defeat the purpose of such support.

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[101] Richard Sullivan, Department of Health and Human Services, personal communication.

Several existing Federal programs provide unrestricted funds in support of university R&D in proportion to project award funding.[102] For example, since 1961, the National Institutes of Health (NIH) has provided funds to universities under its Biomedical Research Support Grant program (and its predecessors) on a formula basis, taking into account the amount of its Public Health Service (PHS) awards in the previous year.[103] To be eligible to apply for such a grant, a university must have received at least three PHS grants worth $200,000. In FY 1984, nearly $37 million was distributed in 392 awards under this program, which is equivalent to about 1.5 percent of all NIH R&D funds awarded to universities in 1984. (This is approximately the same amount as the IR&D funds that would have been available under the withdrawn OMB 1981 proposal.) In a companion program, NIH made about 100 awards totalling nearly $17 million under its shared Instrumentation Grant program.[104] Only institutions in receipt of Biomedical Research Support Grants can apply to this program.

From 1961 through 1974, the National Science Foundation made 939 awards totalling $135 million under its Institutional Grants for Science program.[105] These grants were made available on a formula basis in proportion to previous awards for R&D. Until 1970, the basis for the formula was NSF awards, when it was extended to cover all Federal awards except those from the PHS. The program ". . . was intended to sustain and improve the quality of academic science in institutions that had already shown evidence of quality through winning NSF research awards. . . ." Grants were renewable annually and undesignated except that they had to be used for direct costs of research activities. University presidents were able to use their discretion as to how the award would be used.[106]

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[102] United States General Accounting Office, Report to the Chairman, Committee on Science and Technology. University Funding: Federal Funding Mechanisms in Support of University Research. Report GAO/RCED-86-53, February 1986. This report includes a compilation of a number of such programs, either in effect today, or implemented at some time during the last two decades.

[103] Ibid, pages 132, 134.

[104] Ibid, page 135.

[105] Ibid, page 141.

In addition to these programs of formula grants to institutions, NIH and NSF have had programs of fellowships for senior university faculty to assist them in exploring new research areas. From 1956 to 1971, NSF supported 1,132 individuals with grants of three to 24 months for sabbaticals under its Senior Post-doctoral Fellows program.[107] Since 1980, NIH has made 18 awards totalling $536 thousand to ". . . allow experienced scientists to make major changes in the direction of [their] research careers, and to acquire new research capabilities." [108] These programs facilitated the transitions of individuals to new areas, and did not represent attempts to strengthen institutions themselves. According to GAO, the NSF program was dropped in favor of supporting individual investigators through research projects.[109]

### *e. Bid and Proposal Costs (B&P)*

As noted earlier, the current OMB Circular A-21 allows for the recovery by universities of an allocable portion of the costs of preparing bids and proposals as overhead on research grants and contracts. Furthermore, HHS reports that they currently reimburse universities under this provision.[110] However, no data have been assembled on the aggregate costs of bid and proposal costs that are reimbursed.[111] Bid and proposal costs are subsumed within broader categories of indirect costs, such as "general administration and general expenses", "departmental administration", and "sponsored projects administration", and could not be separately identified without the expenditure of consider analytical effort.

Conceptually, a portion of sponsored projects administration costs are devoted to processing proposals and to negotiating grants and contracts, and these are clearly "bid and proposal" costs. Similarly, a portion of departmental and institutional administration expenses are incurred in connection with the time and effort required to prepare, review and approve project proposals. Both of these categories of costs are apparently covered under current B&P cost allocation practices.

However, perhaps the most costly of all parts of the process of preparing university research bids and proposals—the time and effort of faculty and senior research staff—is not generally separately accounted for or budgeted by universities. In fact, such efforts typically go unrecognized when allocations of an individual researcher's time are made by university administrators. From the perspective of the individual faculty member, the time spent in preparing bids and proposals is typically paid for by short-changing other activities for which he is paid, such as teaching, student advising, sponsored research, and separately-budgeted research paid for from university funds, or by volunteering personal time for the purpose. Only in unusual circumstances do universities explicitly budget for bid and proposal activities, and this is usually on a one-time basis in connection with the coordination of major initiatives involving multiple investigators. Typically, when representatives of the interests of the university community have addressed these costs of research, they have sought greater flexibility and less accountability for the use of faculty time, rather than explicit compensation for faculty time devoted to B&P.[112]

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[106] Ibid.

[107] Ibid, page 111.

[108] Ibid, page 105.

[109] Ibid, page 111.

[110] Richard Sullivan, op. cit.

[111] Ibid.

### *f. Concluding Observations*

When the outlines of the existing Federal government-university R&D relationship were established in the 1940's and 50's, the assistance character of that relationship, combined with the relatively low level of such support and the relatively simple agency requirements for preparing research proposals and for administering Federal funds meant that the costs of maintaining the research infrastructure and of faculty time in raising funds could reasonably be absorbed by general university funding. However, as the dependence of the research universities on the Federal government, and vice versa, has grown, along with the paperwork requirements of that relationship, the relationship has become more akin to that of the defense contractors with DOD, in which their survival in their current form is dependent on essentially a single client: the Federal government. Thus, the problem of compensating the universities for greater fractions of their costs of doing R&D, including IR&D and B&P costs, has become more acute. Congress may wish to consider adopting a mechanism akin to the DOD IR&D/B&P mechanisms to help solve it.

## G. SUMMARY OF ISSUES REGARDING IR&D

For a number of years, DOD, NASA and other agencies have allowed contractors to recover a portion of their independent research and development expenditures as overhead payments on procurement contracts. It is argued that this practice creates an incentive for contractors to spend more of their own funds on research and development than they might otherwise, and that it offers advantages to DOD in comparison with direct procurement of research and development because it allows for greater flexibility and variety of R&D project selection, and because it allows for more rapid response by contractors to changing technical needs and opportunities to develop new defense technologies.

The process by which DOD decides the amounts of IR&D costs that contractors can recover is complex, arcane, not widely understood outside the defense community, and not easily subject to detailed congressional oversight. For this reason, because of the relatively large sums of Federal reimbursements involved (nearly two billion dollars in FY84), and because of genuine differences of view as to whether the IR&D mechanism is the most effective and fair way to support research and development for defense needs, the IR&D mechanism has been the focus of continued controversy. Furthermore, some critics charge that IR&D contributes to the continued race to develop ever-more sophisticated and destructive weapons.

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[112] National Commission on Research, op cit.

No one has successfully demonstrated the effectiveness or superiority of IR&D in comparison with other approaches to defense R&D funding. Despite a number of studies by the General Accounting Office, the National Research Council, DOD, and outside experts it remains difficult to evaluate the IR&D mechanism. Most existing assessments are based on anecdotal accounts of specific accomplishments, either via IR&D or via direct contracting for R&D. However, a showing of cases on either side does not offer conclusive evidence of the value, or lack thereof, of the IR&D approach. An ongoing study by the Rand Corporation for DOD, required under the 1986 DOD Appropriations Act, may offer some new insights into these issues.

For some time, there has been interest in applying a mechanism similar to IR&D for the support of certain indirect costs that universities face in maintaining the infrastructure (facilities, equipment, new faculty) of research and graduate education. Such a mechanism might apply not only to DOD and NASA, but to all of the agencies that support university research. Proposals of this sort considered or made during the late 1970s and early 1980s have not received universal support and have not become Federal policy. The major university research supporting agencies have taken some actions in the last five years or so to address these needs using direct funding rather than an indirect, IR&D-type funding mechanism.

## CHAPTER IX

# THE IMPACTS OF DOD RESEARCH POLICIES ON U.S. SCIENTIFIC AND TECHNICAL PERSONNEL*

Measures of scientific and technical personnel needs typically are crude and imprecise because of data gaps and because such measures use different assumptions about supply and demand. Despite these problems, this chapter raises issues regarding the extent to which the military is using the U.S. scientific and technical work force and summarizes some of the efforts being made by the military to augment the Nation's supply of scientifically and technically trained personnel.

It has been reported that Soviet scientists and technologists outnumber technically trained American personnel, giving additional possible cause for concern about the size of the U.S. research and development personnel pool. Details on the numbers of U.S. and Soviet technically trained personnel were provided by Dr. Edith W. Martin, former Under Secretary of Defense for Research and Development:

> Nearly 90 percent of all scientific knowledge has been generated in the last 30 years. This knowledge base will double again in the next 10–15 years. Furthermore, 90 percent of all scientists in the history of the world still are working. Their numbers will double again in the next decade or so. If current trends continue, in the next 10 years the Soviets will contribute three million scientists to the total number and the US 600,000. Be it three million Soviet engineers or 50 percent of the Ph.D.s educated in the US, these scientists are bound to be productive, bound to turn some force-multiplying, pacesetting ideas into realities. Worldwide technological progress is inevitable. The questions are will the US play a key role in this technology development and will it be available for use in our defense.[1]

At the same time, some experts contend that the demands of conducting military research excessively drain the Nation's scientific and technical personnel pool so that U.S. commercial and industrial competitive potential may be jeopardized. As a result, questions are often raised about the military's responsibilities to support the training of scientific and technical manpower for its own needs as well as to compensate for its direct and indirect economic utilization of personnel who might otherwise work in the civilian sector.

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[1] Martin, Edith. Managing Science and Technology For the Future, Defense Sciences, DS 2003+, Aug./Sept. 1985: 48.

This chapter summarizes information about the size and effects of military manpower needs on the Nation's scientific and engineering personnel pool and describes efforts made by the military to augment the size of the Nation's scientific and technical workforce.

## A. HISTORICAL VIEWS

Estimates about the number of the Nation's scientists and engineers who work in military-related activities vary. In the early 1960s "the technological lag in such industries as housing construction, shipbuilding, and textiles in comparison with Europe and Japan was ascribed by one respected observer largely to the diversion of technical people into government programs." [2] Dr. Harvey Brooks, a scholar in the science policy field, observed, in 1970, that "It is probably true that over 50 percent of industrial employment of scientists and engineers is at least indirectly related to space, defense, and nucler energy . . . ." [3] However, he conceded that ". . . the struggle of such industries to diversify, though fraught with difficulty, is ultimately likely to diffuse much of this effort and sophistication towards civilian problems." [4] Thus it was concluded that American productivity and economic growth were probably affected by the concentration of resources in the defense and space areas. Also, Brooks concluded that there was, in 1970, a reorientation in engineering education to stress aerospace and electronics, to serve the defense and space fields. Concerns over these directions prompted the President's Science Advisory Committee (PSAC) to mount several studies to evaluate governmental actions in these areas.[5] In response to these concerns there also were congressional hearings devoted to enhancing the "technology transfer and utilization" programs of NASA and other agencies. The emphasis on transfer was extended in the late 1960s to include the transfer of management techniques, or what came to be known as the systems approach to problem solving.[6]

## B. CURRENT ESTIMATES OF MILITARY UTILIZATION OF THE NATION'S SCIENTISTS, ENGINEERS, AND TECHNICIANS

Colonel Donald I. Carter, Acting Deputy Under Secretary of Defense for Research and Advanced Technology, testified before the House Task Force on Science Policy in 1985 that about 17 percent of the Nation's scientific and technical personnel engages in military-related work. He stated that:

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[2] Brooks, Harvey. Impact of the Defense Establishment on Science and Education. Appendix E. in U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. National Science Policy, H. Con. Res. 666. Hearings, July, Aug. and Sept. 1970. 91st Congress, second session. Washington, U.S. Govt. Print. Off., 1970, p. 958.

[3] Brooks, op. cit., p. 960.

[4] Brooks, op. cit., p. 960.

[5] One was a study of scientific manpower, undertaken by a panel under the chairmanship of Professor Edwin Gilliland and of M.I.T. and the other was a study of civilian technology and innovation undertaken by a panel under the chairmanship of Dr. Milton Harris, Director of Research of the Gillette Company. [Other studies were conducted by the Department of Commerce.] (Brooks, op. cit., p. 958.)

[6] Brooks, op. cit., p. 958.

There are approximately 2.9 million scientists and engineers (S&E's) at work in the nation. We employ 105,000 (3.6%) of them in our civilian and military workforce of 3.1 million people. Of these S&E's approximately 78,000 are civilians—72 percent of whom are engineers—27,000 are military officers.

DOD also employs almost 740,000 technicians, 22,000 of whom are civilians. About 715,000 technically qualified individuals are in the military enlisted force; they account for 40 percent of total enlisted personnel.

Beyond the 105,000 civilian and military S&E personnel directly employed by the Department, another 13 percent of the nation's total S&E workforce is directly linked to Defense budgets and programs.[7]

## C. EFFECTS OF MILITARY DEMAND ON THE SUPPLY OF SCIENTIFIC AND TECHNICAL PERSONNEL

Estimates vary about the effects of military demands on the personnel supply. Some analysts, have estimated that about 30 percent of the Nation's scientists and engineers are engaged in military-oriented activities.[8] Recently, the argument also has been made that defense spending for the strategic defense initiative (SDI) program will drain significant additional shares of R&D talent from civilian industries and will hurt commercial R&D.[9] A recent report concluded that the SDI ". . . would require the efforts of nearly 15 percent of all physicists in the country by fiscal 1989. . . ." [10] Whatever number of scientific and technical personnel working on military projects, the percentage seems to be significantly lower than in the Vietnam War era, when Dr. Brooks estimated ". . . that over 50 percent of industrial employment of scientists and engineers is at least indirectly related to space, defense, and nuclear energy. . . ." [11]

### 1. DEMANDS PLACED ON SPECIFIC TECHNICAL FIELDS

Generally, studies of the scientific and technical personnel pool show that scientific and technical personnel shortfalls may occur in a few selected areas rather than overall, due to military requirements, but that the military is taking steps to augment the supply. A recent National Academy of Sciences study of the effects of military personnel policies on the production of scientists and engineers concluded that ". . . military personnel requirements under less than major increases in force levels or mobilization conditions will not have a heavily negative effect on the output of scientists and engineers."[12] However, while military recruitment and manpower needs may not affect the production of scientists and engineers, it is generally acknowledged that military RDT&E spending will utilize significant portions of manpower supply in certain fields. For instance, the following observation was made regarding the military demand for ceramics engineers, suggesting negative impacts for civilian trade:

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[7] The Department of Defense Statement on Science in the Mission Agencies and Federal Laboratories. By Col. Donald I. Carter, USAF. Before the Task Force on Science Policy of the Committee on Science and Technology of the U.S. House of Representatives, Oct. 2, 1985, pp. 5–6.

[8] Dumas, Lloyd L. University Research, Industrial Innovation, and the Pentagon. In Tirman, The Militarization of High Technology, op. cit., p. 138.

[9] Guterl, Fred V. Star Wars is Bad for Business-It Won't Lead to Major Commercial Spinoffs and It Will Hurt Business R and D, Military Technology Experts Say. Dun's Business Month, Sept. 1986, as cited in Why Star Wars is Bad for Business, In Extension of remarks of Hon. Robert W. Kastenmeier, Congressional Record, Sept. 8, 1986: E3006–3007.

[10] Star Wars Will Devastate More Essential Military Research. Congressional Record, Feb. 6, 1986: S1090-S1091.

[11] Brooks, op. cit., p. 960.

> . . . [T]he military has long employed some of the nation's best ceramic engineers. The Navy recently announced a new underwater ceramic microphone that is 1000 times more sensitive than its predecessor. Meanwhile the Japanese have taken the lead in the commercial use of ceramics in everything from ceramic scissors to gas engines.[13]

According to a recent National Science Foundation study, entitled *Projected Response to the Science, Engineering, and Technical Labor Market to Defense and NonDefense Needs: 1982–87:*

> The defense industrial base is highly dependent on [science, engineering, and technician] SET personnel; roughly 15 percent of the defense work force is employed in SET occupations as opposed to 3 percent of that in nondefense. Because defense spending is concentrated in high-technology manufacturing industries, SET employment projections show a marked sensitivity to variations in defense spending despite the latter's small share of GNP. During the 1982–87 period, projected growth in employment for SET personnel is much stronger in defense-than in nondefense-related activities. By 1987, roughly 4 percent of scientists, 15 percent of engineers, and 7 percent of technicians are projected to be employed in defense activities, a slight increase over the 3 percent, 12 percent, and 6 percent, respectively, employed in such activities in 1982. Among SET occupations, defense expenditures have their strongest impact on the engineering work force.[14]
>
> Growth in requirements for SET personnel is projected to be concentrated in a few industries that are also an important part of the defense industrial base. Five industries are projected to generate about three-quarters of the net increase in requirements for engineers—electrical machinery, fabricated metals, nonelectrical machinery, transportation equipment (including aircraft), and business services.[15]

Most recent studies find that usually the overall supply of scientific and technical manpower adjusts sufficiently over the long-term to fulfill market demands. According to Rodney Nichols, Executive Vice President of Rockefeller University, some analyses suggest that for technical personnel ". . . rising military R&D spending, through the usual market pulls with a lag of a few years, creates its own technological labor force." [16] However, there may be short-term lags in specific highly demanded fields, esecially those linked to high growth technological areas or to defense indistries.[17] The National Science Foundation study defines shortages in supply as ". . . a 5-percent, or greater, shortfall in supply of new, appropriately trained college graduates and experienced workers." [18] In 1984, the Foundation estimated there would be shortages exceeding 10 percent of the workforce by 1987 in several areas especially important to the military. Specifically, shortfalls were projected in three areas: computer specialists, aeronautical/astronautical engineering and electrical/electronic engineering. The last two areas ". . . are expected to be seriously affected by the level and pattern of the defense buildup." [19] The projected shortage of electrical and electronics engineers would occur if high levels of defense spending coincide with rapid economic growth. In that case the report expected that there may be a shortage of 10 percent, or 30,000 workers. Defense industry needs may also cause a shortage in technical and aircraft mechanics.[20] According to the report, many of the jobs in the areas affected by shortages—that is, computer specialists, aeronautical and astronautical engineering, and electrical and electronics engineering—would be filled by underqualified workers and by persons shifted from other occupations. Data are not yet available to assess the accuracy of these projections.

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[12] The effect of Military Personnel Requirements on the Future Supply of Scientists and Engineers in the United States. Papers and a Conference Report. Washington, National Research Council of the National Academy of Sciences. 1981, p. ii.

[13] Military Research and the Economy: Burden or Benefit? The Defense Monitor, v. xiv., no. 1, 1985, p. 2.

[14] U.S. National Science Foundation. Projected Response of the Science, Engineering, and Technical Labor Market To Defense and Nondefense Needs: 1982–1987. Washington, DC. 1984, p. vi. (Special Report NSF 84-304.)

[15] Ibid., p. iv.

A more recent National Research Council report, entitled *The Impact of Defense Spending on Nondefense Engineering Labor Markets,* was more sanguine regarding the military impact on engineering:

> The engineering labor market has exhibited a high degree of resiliency to the shocks of external forces, such as wide fluctuations in defense spending. . . .
>
> The current defense buildup represents a relatively small incease when compared with earlier buildups. . . .
>
> Although the current demand for engineering services is high, evidence drawn from a variety of sources does not suggest pervasive or serious industrial shortages. However, problems may exist in particular fields requiring highly specific training, such as optics, and shortages of engineering faculty have been well documented. . . .[21]

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[16] Nichols, Rodney. Testimony at hearings before the Science Policy Task Force, Oct. 1985, p. 5.

[17] See for instance: U.S. Office of Technology assessment. Demographic Trends and the Scientific and Engineering Work Force. A Technical Memordandum. Washington, U.S. Govt. Print. Off., Dec. 1985, 145 p.

[18] Projected Response of the Science, Engineering and Technical Labor Market to Defense and Nondefense Needs: 1982-87, op. cit., p. vi.

[19] Ibid., p. 21.

[20] Marsh, Robert T. Our Dangerous Shortfall in Technical Education. Air Force Magazine, Dec. 1985: 37.

[21] The Impact of Defense Spending on Nondefense Engineering Labor Markets. A Report to the National Academy of Engineering. By Panel on Engineering Labor Markets. Office of Scientific and Engineering Personnel, National Research Council. Washington, D.C., National Academy Press, 1986, p. v.

It concluded that more research was needed to understand these parameters because "Quantitative models of engineering manpower supply and demand developed thus far are inadequate to predict effects of future defense program requirements on the civilian economy or other similar issues." [22]

### 2. IMPLICATIONS FOR MILITARY MANPOWER

The shortages in specific fields occur not only in civilian personnel working for defense industries and for the Defense Department, but also in the officer corps of the Army, Navy, and Air Force, which have experienced shortages in technically trained manpower as personnel are attracted by higher salaries in industry. But shortages may be mitigated to some extent because turnover among Defense Department research personnel appears to have been constricted by current DOD personnel policies and statutes that prohibit personnel, at least temporarily, from accepting employment at firms with which they have had contractual relations during Government service. Such personnel policies, according to James A. Tegnelia, acting Director of the Defense Advanced Research Projects Agency (DARPA), tend to ". . . stifle one aspect of creating technological changes in the Agency's programs." [23] To ameliorate some of these problems, Robert S. Cooper, former Assistant Secretary of Defense and director of DARPA, recommended the establishment of new liberalized personnel polices for scientists and engineers, with salary inducements, a cut in hiring lead times, liberalization of conflict of interest policies, and special status employment categories for these special employees.[24]

### 3. THE "SPILLOVER" ARGUMENT

It is maintained that many of the skills and talents of scientists working for defense or in defense industries will diffuse towards civilian problems as defense industries diversify.[25] This "spillover" argument is often invoked to counter claims of negative impacts from defense utilization of scientists, engineers, and technicians that might otherwise be employed to greater economic benefit in the civilian economy. There are several arguments which may undermine the spillover argument. As noted in chapter XIII of this study, questions have been raised about how much spillover really occurs, whether it is an efficient investment strategy to expect civilian technology to be enhanced by spillover from military technology, and whether direct funding of civilian technology would be a more efficient innovation policy. Arguments have also been made that the creativity of scientists who conduct most of their work for the Pentagon, is adversely affected by the requirements of secrecy, overspecialization, and the need for retraining of their skills if they seek to diversify by doing civilian work.[26]

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[22] Idem.

[23] Testimony of James A. Tegnelia, op. cit., p. 5.

[24] Testimony of Robert S. Cooper, before the Task Force on Science Policy, op. cit., Oct. 23, 1985, p. 8.

[25] Brooks, op. cit. p. 960.

[26] Davis, Warren F. The Pentagon and The Scientist. In Tirman, The Militarization of High Technology, op. cit., pp. 153–179.

## D. ACTIVITIES UNDERTAKEN BY THE MILITARY TO INCREASE THE NATION'S SUPPLY OF SCIENTISTS AND ENGINEERS

Over the years some military officials have complained that the U.S. educational system is not training sufficient numbers of scientific and technically literate generalists and specialists. They contend that this will ultimately jeopardize not only our potential high technology trade, but also our national security.[27] The points are often made that students in other countries, such as our economic competitor, Japan, often outperform U.S. students in tests of scientific, technical and mathematical competence; that foreign students are enrolling in increasingly larger number in some U.S. graduate science and technology programs; [28] and that at the Ph.D. level over 50 percent of U.S. doctoral degrees in some engineering fields are awarded to foreigners. According to the National Science Board report *Science Indicators,* during 1984, 55.4 percent of doctoral degrees in engineering awarded by U.S. universities were to foreign students.[29] The scientific and technical fields in which high percentages of U.S. doctoral degrees were awarded to foreigners include: physics and astronomy, 29 percent to foreigners; mathematics, 39 percent to foreigners, computer sciences, 37.5 percent to foreigners, and agriculture and forestry, 29 percent to foreigners.[30] Some observers contend that many of these Ph.D. degree recipients augment U.S. teaching staff and ultimately may become American citizens and enlarge the pool of manpower available for defense work.[31] But this is unlikely according to Dr. Donald I. Carter, Acting Deputy Under Secretary of Defense for Research and Advanced Technology, who testified before the Task Force on Science Policy on Oct. 5, 1985 that:

> The number of Ph.D.s in engineering awarded to U.S. citizens by U.S. universities declined steadily throughout the 1970's and early 1980's with a net decline of 42 percent between 1968 and 1982. Nearly half of all engineering Ph.D.'s are now awarded to foreign nationals. Foreign engineering Ph.D.'s even if they remain in the U.S., generally cannot obtain U.S. security clearances and are thus not available for direct DoD employment.[32]

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[27] Marsh, Robert T. Our Dangerous Shortfall in Technical Education. Air Force Magazine, Dec. 1985: 36-39 and Orr, Verne. Are we a Nation of Scientific Illiterates? American Education, v. 19, Apr. 1983: 24-025, 35-36.

[28] According to the National Science Board: "Growth in foreign student participation in S/E graduate education continues to exceed that of U.S. citizens. . . . Foreign student participation . . . accounted for 85 percent of the next growth in the number of full-time S/E graduate students in doctorate-granting institutions between 1980 and 1983. The rapid growth of foreign graduate enrollments in certain fields has meant that foreigners are constituting increasing proportions of the total enrollments in those fields. Thus, by 1983, foreign students represented 42 percent of all full-time graduate enrollments in engineering, 40 percent in mathematics, 38 percent in the computer sciences, and 29 percent in the physical sciences." (U.S. National Science Board. Science Indicators: The 1985 Report. Washington, U.S. Govt. Print. Off., 1985, p. 101.)

[29] Science Indicators, 1985, op. cit., p. 298.

[30] Idem.

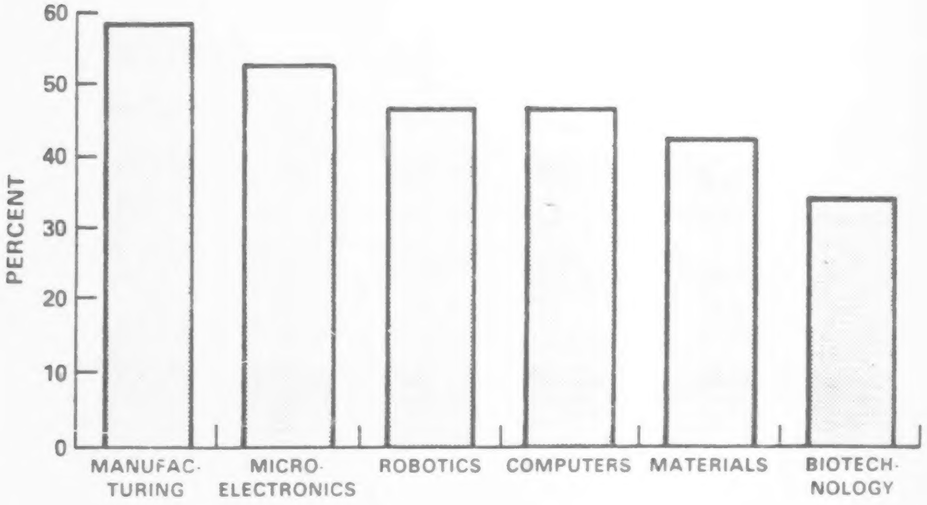
[31] For a variety of views, see: Cooper, Edith Fairman. Supply and Demand for U.S. Scientists and Engineers: Brief Overview of the Current Situation and Future Outlook. Congressional Research Service, Library of Congress, Feb. 18, 1987, 34 p.

[32] Carter, Colonel Donald I. The Department of Defense Statement on Science in the Mission Agencies and Federal Laboratories. Testimony Before the Task Force on Science Policy, House Committee on Science and Technology, Oct. 2, 1985, p. 15-16.

According to Carter foreign doctoral students comprise about 50 percent or more of the doctoral students population in defense related engineering areas, including manufacturing, microelectronics, robotics, computers, and materials. See Table IX. I.

Figure IX A

Foreign Doctoral Students in Emerging Engineering Areas: 1984*



SOURCES. NATIONAL SCIENCE FOUNDATION AND AMERICAN COUNCIL ON EDUCATION

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* The Deprtment of Defense Statement on Science in the Mission Agencies and Federal Laboratories. By Colonel Donald I. Carter, USAF, Acting Deputy Under Secretary of Defense for Research and Advanced Technology, Before the Task Force on Science Policy, Oct. 2, 1985, p. 5.

In the past, the Government has reacted to military/security exigencies or threats by developing programs to heighten the emphasis on science and mathematics teaching in the schools and to support supplementary programs at high school and college levels. The passage of the National Defense Education Act in 1958 is one illustration. Another is the exemption given to science and technology graduate students under 1970s Selective Service policies. (For additional information, see chapters III and V in this anthology.) In addition, the military services have attempted over the years to develop programs to help train scientists and engineers, and as a National Academy of Sciences report observes: "Indeed, under some combinations of policy alternatives, military personnel policies might increase this supply." [33]

It was estimated in a 1981 study that "in the aggregate, the Reserve Officer Training Corps (ROTC) supplied about 57 percent of the 7,938 officers with scientific and engineering disciplines who entered the Armed forces in FYs 1980 and 1981." [34] About 29 percent came from the military academies and the remaining 14 percent came from other sources, such as officer candidate programs and voluntary recall of reserve officers.[35] Because the military Services view the ROTC program as such a "productive source for officers with engineering and other technical disciplines, they are expanding their ROTC scholarship programs." [36] Details (as of 1981) were:

> In 1980, Congress authorized the Army an additional 5,500 ROTC scholarships for a maximum total of 12,000. The . . . Uniformed Services Pay Act of 1981 authorized 3,500 more ROTC scholarships (for a maximum of 9,500) for the Air Force and 2,000 more (for a maximum total of 8,000) for the Navy.
>
> The Air Force adopted a policy in 1979 that 75 percent of its ROTC scholarships must be awarded to students pursing scientific, engineering, and technical degrees. . . . In 1976, the Navy established a goal that 80 percent of its *ROTC entrants* would be pursuing majors in the technical disciplines.[37]

For additional information on these and other science and engineering education training programs, see the appendix to this chapter.

The Department of Defense employs 50 percent of all scientists and engineers employed by the Federal Government (67 percent of all engineers and 26 percent of all scientists employed by the Federal government.) [38] As noted above, scientists may leave the Government because of the attractiveness of higher salaries in the private sector. Recently, several agencies including the Navy, Air Force, the National Bureau of Standards and the Central Intelligence Agency, have been conducting demonstration studies to determine if the civil service compensation system can be simplified, and at the same time increase productivity, while seeking to reward the performance, especially of scientific and technical personnel on a salary basis comparable to the private sector. (Authorized by Title VI of the Civil Service Reform Act of 1978.) Legislation was introduced but not enacted during the 99th Congress to implement supplementary personnel compensation policies for scientists and engineers government-wide, (S. 1727, 99th Congress) and to enable agencies to implement changes in their compensation plans on a basis similar to the Navy experiment at China Lake (H.R. 5388 and S. 2724.)

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[33] The Effect of Military Personnel Requirements on the Future Supply of Scientists and Engineers in the United States, op. cit., p. ii.

[34] Zinsmeister, Paul. Engineering Manpower: A Survey of the National Problem and the Problem in the Department of Defense. Congressional Research Service, Library of Congress, Dec. 31, 1981, p. 14.

[35] Zinsmeister, op. cit., p. 14.

[36] Zinsmeister, op. cit., p. 15.

[37] Zinsmeister, op. cit., 15.

[38] Calculated from U.S. National Science Foundation. Federal Scientists and Engineers: 1985. Washington, U.S. Govt. Print. Off., 1985, Table B-1.

Several initiatives were made by the Services recently to increase the supply of scientists and engineers. In order to retain qualified scientists and engineers as active duty military officers, the Uniformed Service Pay Act of 1981 (P.L. 97-60) enables each military Service to supplement the salaries, or more precisely to pay continuation pay, to military personnel serving in scientific and engineering positions determined to be critically short of requirements. "The law authorizes payments of up to $3,000 for each year of service such officers agree to serve on active duty." [39]

Research, training, and faculty support programs administered by the military Services are intended to serve the objectives of generating additional trained personnel to meet military needs and to strengthen the quality and quantity of university faculty. These programs have been described in a variety of sources, including testimony of military officials at hearings held by the Task Force on Science Policy of the House Committee on Science and Technology, DOD's report, *Basic Research, 1985*, and in articles by Dr. Edith W. Martin, former deputy under secretary of Defense for Research and Advanced Technology.[40] Some of these programs appear to have been initiated in response to recommendations made by the DOD University Forum Working Group on Engineering and Science Educaton in 1983 [41] and a study report prepared by the Defense Department in 1985 on *The Technology Base and Support of University Research,* made in response to concerns expressed by the Senate Committee on Armed Services in a report dated May 31, 1984.[42] These programs are listed next.

### 1. DIRECT FUNDING OF UNIVERSITY RESEARCH AND GRADUATE STUDENTS

The DOD contends that university research funding from the 6.1 program serves two purposes. Not only does it generate new research and technology, but, according to a 1980 Navy study ". . . on a average, a million dollars of 6.1 university research funding provides financial support for approximately 10-15 graduate students. On that basis, our research program provided financial assistance for well over 4,000 graduate students in 1984." [43]

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[39] Zinsmeister, op. cit., p. 12.

[40] U.S. Department of Defense. Basic Research Program. 1985. Washington, U.S. Govt. Print. Off., 1985, pp. 3-4 and Martin, Edith W. DOD Research: Today's Challenges and Implications for Tomorrow. Grants Magazine, vol. 6, Sept. 1983: 154-156.

[41] Report of the DOD-University Forum Working Group on Engineering and Science Education. Washington, Office of the Under Secretary of Defense for Research and Engineering, July 1983, 51 pp. plus appendices.

[42] U.S. Department of Defense. Report on The Technology Base and Support of University Research. For the Committees on Armed Services, U.S. Congress, Mar. 1, 1985, 83 p.

### 2. FACULTY SUPPORT

In order to expose university faculty to DOD research needs, DOD sponsors a program of summer research for faculty in DOD laboratories. In 1983, more than 300 faculty members and 50 graduate students participated.

### 3. COLLEGE FACULTY AND STUDENT SUPPORT

Basic research programs indirectly support many graduate students through grant and contract research programs. In addition, a section of the Defense Authorization Act of 1982 enables the R&D laboratories to contract with educational and nonprofit institutions for the research services of college and university students.

### 4. GRADUATE STUDENTS

The Army, Navy, and Air Force have fellowship support and specialized graduate assistantship programs. In fiscal year 1983, the Services supported more than 100 fellows in defense-related scientific and technical disciplines. The program was estimated to have supported almost 200 students in 1984.[44] The Air Force has contracted with various industries and universities to create graduate education programs in thermionic engineering, composite structures, aircraft propulsion, and manufacturing sciences. The Army allocated funding for about 250 fellowships in FY83. This is an increase from six fellowships in FY82. In 1983, the Navy supported 41 students in electrical engineering, computer sciences, naval architecture, applied physics, materials sciences, and mechanical and aerospace engineering. The American Society for Engineering Education manages the fellowship program for the Navy.

### 5. HIGH SCHOOL STUDENTS

In 1981, DOD initiated a science and engineering apprenticeship program for high-school students. DOD estimates that from 1980 to 1985 over 2,000 high-school students worked in DOD laboratories or with university researchers under contract to DOD. The program provides students with exposure to research techniques under the guidance of a senior mentor and alerts them to the need to take appropriate math and science courses while still in high school.

## E. SUPPORT OF UNIVERSITY RESEARCH CAPABILITY

The Defense Department administers several programs intended specifically to augment university research capability. They are the university research instrumentation program, the university research initiative, and enlarged programs of university/industry cooperation, and other programs. These are briefly described next. (For additional details, see in this report chapter V, "Overview of DOD Support for Research at Colleges and Universities.")

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[43] Carter, Testimony, Oct. 2, 1985, op. cit., p. 16.

[44] Department of Defense. Basic Research Program. Washington, U.S. Govt. Print. Off., Sept. 1985, p. 3.

### 1. UNIVERSITY RESEARCH INSTRUMENTATION

In order to deal with the serious issue of obsolete university equipment, in the fiscal year 1983 the Defense Department initiated a University Research Instrumentation Program with $30 million per year for a five-year period for "items of equipment in the $50,000 to $500,000 price range which can be used in research of primary concern to the Services." [45]

### 2. DOD-UNIVERSITY RESEARCH INITIATIVE

During the fiscal year 1986 the DOD initiated a program to strengthen the scientific infrastructure at universities. Initially $25 million was requested, approximately $4–6 million for each of the three Services and DARPA. Congress subsequently increased this amount to $100 million. The program contains two emphases:

> The first . . . includes fellowship, assistantship, exchange scientists and instrumentation programs. The first three, "people" programs . . . involve . . . in-house laboratories and scientific research offices with the objective of enhancing the nation's science and engineering capability and, at the same time, strengthening the interaction between in-house laboratory and university researchers. The second thrust . . . will be the initiation of multidisciplinary science and engineering research programs in a number of high risk, potentially high payoff areas such as materials and structures, fluid mechanisms, aeronautics, biotechnology, communication networks, computer science, microelectronics, and optical materials. The intent is to support programs which concentrate talent to achieve the "critical mass" required to accelerate research achievement. These multidisciplinary programs will be managed through a Tri-Service and DARPA commitment which will provide close coordination with DOD and a single point of focus for the universities.[46]

### 3. UNIVERSITY/INDUSTRIAL COOPERATION

Independent Research and Development is defined as R&D that industry conducts, that is reimbursed through allowed overhead on DOD and NASA contracts. The DOD is attempting to develop stronger university/defense/industry ties by means of a new IR&D policy. This new policy, approved by the DOD IR&D Council on October 26, 1982, will encourage defense contractors to increase their total university interaction by various means, including research contracts, grants, faculty support and consulting, graduate student support, employee training, co-op and summer programs, sharing research equipment, and allowing staff to teach or serve on academic committees.[47]

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[45] Carter, Testimony, Oct. 2, 1985, op. cit., p. 17.

[46] Carter, Testimony, Oct. 2, 1985, op cit., pp. 17-18. See also: The Department of Defense FY1986 University Research Initiative Program Overview. Washington, Department of Defense 1986, 60 p.

### 4. OTHER PROGRAMS

The DOD has established specialized Centers of Excellence in science and technology at major universities throughout the country in order to generate the kinds of research needed to support the defense missions.[48] More recently the Defense Department has established the Software Engineering Institute to do advanced research and training in information sciences. This undoubtedly will stimulate the training of additional graduate students. The proposed Strategic Defense Initiative Institute may also affect education in areas related to development of lasers, electronics, and physics.

### 5. PROGRAM DESCRIBED ACCORDING TO SERVICE

See the appendix to this chapter for an overview of selected educational training programs listed by Service sponsor.[49]

## F. Concluding Observations

This chapter raises issues regarding the draw exercised on the scientific and technical work force by economic and career inducements to meet military needs; the chapter also summarized some efforts being made by the military to augment the Nation's supply of scientifically and technically trained personnel.

There is evidence that demand for military research and development may deplete supplies of some types of scientific and technical workers in the short-run and as long as defense contractors can outbid others for the services of these specialists. However, the long-term effects of such economic demand is less clear, because normal market mechanisms tend to increase supply. However, some military decision makers are also concerned about the implication of the fact that the Soviet Union produces far more technically trained personnel than the United States. The issue of scientist supply and demand requires additional study, particularly about the extent of personnel shortages in specific fields in great demand by both the military and civilian sectors of society and the economy. Significant questions remain also about the possible detrimental effects on the U.S. research system and especially on the military research system of the fact that more than 50 percent of U.S. university graduate level students in some areas of science are foreigners, most of whom will not be able to do research for the U.S. defense system after receipt of the Ph.D. This also has implications for civilian manpower requirements and U.S. commercial research and development capabilities.

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[47] For additional information on IR&D, see in this report chapter VIII, "DOD Support of Independent Research and Development in Industry: Issues and Implications for Federal Civilian R&D."

[48] As of Sept. 1985, these include DOD programs: Joint Services Electronics Program at: Georgia Tech, MIT, Columbia, Stanford, Univ. of Illinois, Harvard, Ohio State, Univ. of Southern California, Univ. of Texas, Univ. of California at Berkeley, Cornell; Synthesis and Application of Monomolecular Films, Case Western Reserve; Army Programs: Rotocraft, Georgia Tech, Renssalaer Polytech, Univ. of MD; Artificial Intelligence/Robotics, Univ. of PA., Univ. of TX, Austin; Mathematics, Univ. of WI.; Oceanography, Univ. of Wash, Univ of TX, Penn State; Laser Chemistry, Howard; Polymer Research, Atlanta; Air Force: Ultrastructure Processing (Ceramics, Glass and Composites), Univ. of Florida; Unsteady Aerodynamics, Ilinois Institute of Technology; Manufacturing Sciences, Stanford, Univ. of Michigan; Microwave Tubes, Univ. of Utah; DARPA, Semiconductor Process Modeling, Stanford; Molecular Bean Epitaxy, Cal Tech., Stanford, Univ. of Illinois, NC State; Polymer Structural Applications, Univ. of MA; Synthesis and Applications of Monomolecular Films, Case Western Reserve; Computer Architecture and Design for New Systems, MIT, Carnegie-Mellon, Stanford, Univ. of Southern Calif.; and Submicron VLSIC Design and Architecture, Cal Tech. The Proposed FY 1986 Department of Defense University Research Initiative (URI). Paper Prepared for Discussion at the Sept. 23-24, 1985 meeting of the DOD University Forum Working Group on Engineering and Science Education, Dept. 1985, pp. A-2 to A-4. Prepared by DOD.

[49] Source: U.S. Department of Defense. The Technology Base and Support of University Research. Report for the Committees on Armed Services, U.S. Congress. Mar. 1, 1985, pp. 25-33.

Historically, the military has initiated and continued to support educational and training programs to augment national supplies of scientists, engineers, and technicians. Currently the DOD is sponsoring several programs of this nature. An enduring policy issue is the question of whether DOD should increase its efforts in this regard. Or should Federal agencies charged with supporting nondefense science and technology play greater roles in augmenting personnel supplies? Is Government doing enough now in supporting scientific and technical education?

## APPENDIX

## DOD SCIENCE AND ENGINEERING PROGRAMS [50]

TABLE D.1.—DOD SCIENCE AND ENGINEERING EDUCATION PROGRAMS [1]

| Sponsor | Program title |
|---|---|
| Elementary and secondary: | |
| Army | Junior Science and Humanities Symposium |
| | Science and Engineering Fair Program |
| | Research and Engineering Apprenticeships |
| | Uninitiated Introduction to Engineering |
| | International Mathematical Olympiad |
| | Armed Forces Orientation in Engineering |
| Navy | Research and Engineering Apprenticeships |
| | Pre Co-Op Program |
| | Navy Science Awards Program |
| Air Force | Precollege Technical Orientation |
| | Research and Engineering Apprenticeships |
| | Uninitiated Introduction to Engineering |
| Undergraduate: | |
| Army | ROTC—Hi Tech Scholarship Emphasis |
| | Co-Op Labor Employee Educational Program |
| Navy | ROTC—Science and Engineering Program |
| | Co-Op Education Program |
| | Federal Junior Fellowship Program |
| Air Force | Airman Education and Commissioning Program |
| | ROTC—Science and Engineering Scholarship Emphasis (85 percent for S&E Students) |
| | AF Institute of Technology Undergraduate Engineer Conversion Program |
| | College Senior Engineering Program (CSEP) |
| Graduate: | |
| Army | Graduate Contract Research Programs |
| | Graduate Programs in computer science, electronics, modern optics, hypersonic aero-mechanics and aero-dynamics, and biogenetic engineering |
| | Graduate Programs at Centers of Excellence in Rotary Wing Technology |

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[50] Source: The Department of Defense Report on The Technology Base and Support of University Research. For the Committees on Armed Services, U.S. Congress. Mar. 1, 1985, pp. 25–33.

TABLE D.1.—DOD SCIENCE AND ENGINEERING EDUCATION PROGRAMS [1]—Continued

| Sponsor | Program title |
|---|---|
| Navy | Office of Naval Research-Graduate Contract Research Program |
| | Co-Op Education Program |
| | Graduate Programs in electrical engineering, computer sciences, naval architecture, applied physics, material sciences and mechanical and aerospace engineering |
| | Military Graduate Education Programs |
| Air Force | Graduate Contract Research Programs |
| | Graduate Programs in thermionic engineering, composite structures, aircraft propulsion and manufacturing sciences |
| Special Programs: | |
| All services | Historically Black Colleges |
| | Summer Faculty Research and Engineering Program |
| | Equipment Grants/Research Instrumentation |
| | Post Graduate Fellowships |
| Army | Summer Associateship for High School Science and Mathematics Faculty |
| Navy | ONR Young Investigators Program |

[1] Funded from various DOD sources, not limited to RDT&E funds. Programs which support the voluntary education of uniformed personnel are not included.

## SELECTED ARMY EDUCATION PROGRAMS

The Army has programs in science, mathematics, and engineering education at the secondary, undergraduate, graduate, and postgraduate levels.

Pre-College Education Programs. (i) The Junior Science and Humanities Symposium (JSHS) Program exposes 7,500 secondary students each year to leading scientists in the academic, industrial, and government communities. (ii) 60,000 students annually participate in more than 280 regional, State, and International Science and Engineering (ISEF) Fairs. (iii) Eight talented students are selected competitively from over 400,000 high school participants to represent the U.S. at the annual International Mathematical Olympiad (IMO). (iv) The Uninitiated Introduction to Engineering (UNITE) program provides a select group of socially—and economically—disadvantaged high school students with four weeks of summer instruction and guidance by cooperating universities and Army laboratories. (v) The Research and Engineering Apprenticeship Program (REAP) can extend over several summers and offer mentor/apprentice training for disadvantaged youngsters by university professors. (vi) An intensive, four-week program involving digital logic, microprocessors, robotics, and programming is available in Computer Related Engineering and Science Studies (CRESS).

Undergraduate Educational Programs. The Army's Reserve Officer Training Corps (ROTC) program includes 12,000 students at over 300 universities; recent selections have emphasized science, mathematics, and engineering. Also, the Army has a very active coop work/study arrangement with many colleges and universities.

Graduate Level Educational Program. Over 800 research contracts with universities throughout the United States support, as a byproduct, many graduate students working on the contracts. In addition, last year, the Army awarded 35 graduate fellowships in computer science, electronics, modern optics, hypersonic aeromechanics and aerodynamics, and biogenetic engineering under the Army Fellowship Program.

Special Eductional Programs. Seventeen historically black colleges (HBC) are involved in a special Army effort to sponsor mathematics, engineering, and science research at HBC's; about $1.4 million per year is involved. The Summer Faculty Research and Engineering Program (SFREP) offers 10-week summer appointments in Army laboratories to selected university faculty members; 24 Army laboratories paticipate. The Army has a similar program for high school science and mathematics faculty that involved 90 teachers in first summer of the program.

Postdoctoral Program. Working with the National Academy of Sciences, the Army has about 55 National Research Council Fellows working in several Army laboratories on postdoctoral research. This program is available to new doctoral graduates as well as to more senior researchers at colleges, universities, non-profit research institutes, etc. The program fosters interaction between Army and civilian scientists and engineers, and it has resulted in Army recruitment of many capable young researchers.

### SELECTED NAVY EDUCATION PROGRAMS

The Navy supports science and engineering education at all levels. Several of these programs are run by or in conjunction with Navy laboratories because of their direct need for highly trained personnel.

At the pre-college level, the Navy has programs for hiring science and engineering apprenticeship students at laboratories in the summer. ONR encourages university contractors to involve high school students on research projects. In FY 1983, 335 students were supported under these programs. In addition to participating in regional and state science and engineering fairs, the Navy offers scholarships and other awards in the Navy National Science Awards Competition and the International Science and Engineering Fair.

At the college undergraduate level, the Navy supports three programs; the ROTC Science and Engineering Program, the Co-op Education Program, and the Federal Junior Fellowship Program. In FY 1983, these programs had approximately 7,300 participants.

The Navy supports several significant educational programs at the graduate level. These include the ONR Graduate Fellowship Program, the Co-op Education Program, and the Military Graduate Education Program. The ONR Graduate Fellowship Program is directed toward increasing the supply of U.S. citizens trained in areas of science and engineering of particular importance to current and future naval technology. Started in FY 1982, this program currently supports 40 new fellows per year, who pursue doctoral studies in electrical engineering, computer science, naval architecture, applied physics, material science, mechanical and aerospace engineeing, mathematics, and oceanography. Funding for this program is planned to grow to over $4.5 million by FY 1989, thereby enabling the selection of 50 new ONR fellows per year. This represents a 20 percent increase over the present level.

The Navy supports postdoctoral training at Navy laboratories and under research contracts at universities. The Navy awards Postdoctoral Cooperative Research Associateships through the National Research Council. These associateships can be used at the Naval Research laboratory (NRL), Washington, D.C. and the Naval Ocean Research and Development Activity (NORDA), Bay St. Louis, MS. These competitive awards provide opportunities for doing basic and applies research onsite at NRL or NORDA. A program sponsored by the Office of Naval Technology provides similar opportunities for thirty postdoctoral research fellows each year at the other Navy laboratory centers.

In addition to student support, the Navy provides faculty support. Under the Summer Faculty Research Program, science and engineering faculty members from universities and colleges spend ten weeks in the summer conducting research at Navy laboratory centers. For the last three years, over one hundred university faculty members have entered this program each summer. Participants work with professional peers on research task of mutual interest. Follow-up programs have been found to occur between the laboratories and the faculty members in about 30 percent of the cases. A second program supports research chairs at the U.S. Naval Academy, the U.S. Naval Postgraduate School, the Massachusetts Institute of Technology, and the University of Michigan. The Navy also finances visiting professorships to the U.S. Naval Academy and the U.S. Naval Postgraduate School.

ONR plans to initiate a new program in FY 1985 to identify and support exceptional young investigators who are in tenure track positions at U.S. universities. The ONR Young Investigator Program is designed to encourage younger researchers to take an active role in naval research. ONR will invest $2.0 million in this program in FY 1985.

In addition to its formal educational programs, the Navy also has the Historically Black Colleges (HBC) Council. The Council is an officially established ONR body whose primary purpose is to facilitate relationships between HBC institutions and ONR that may eventually lead to greater HBC participation in the ONR Contract Research Program (CRP). As a result of this and other efforts, ONR spent $2.4 million with HBCs in FY 1984.

### SELECTED AIR FORCE EDUCATION PROGRAMS

The Air Force is supporting science and engineering education through officer commissioning and graduate education programs, civilian personnel programs, and a number of special programs associated with basic research.

Under its officer commissioning programs, in FY 1985 the Air Force will provide 7,500 ROTC scholarships, of which 85 percent are for S&E students. It will also enroll about 400 airmen in the Airman Education and Commissioning Program, of which about 90 percent will be S&E students, and 75 students in the College Senior Engineering Program. In FY 1985, about 525 officers will enter graduate S&E programs.

The Air Force Laboratories, Centers, and Product Divisions also support programs to: (1) introduce high school students to Air

Force technical careers; (2) employ undergraduate S&E students in co-op, stay-in-school, and summer hire programs; and (3) support the technical upgrading of civilian S&E employees through short-term and long-term full time training programs.

At present, about 60 percent of the Air Force basic research program is under contract at universities. This research supports an estimated 1,000 to 1,200 graduate students through research assistantships. In additional to this general support, AFOSR and the Air Force laboratories provide research and educational opportunties for graduate students, post doctoral scientists and engineers, and university faculty through special programs that support research on problems of interest to the Air Force.

The Air Force Office of Scientific Research (AFOSR) supports four graduate student assistantship programs that are focused on research areas of critical interest to the Air Force. The Air Force Thermionic Engineering and Research Program (AFTER) is focused on microwave tube research, a technology that electrical engineers supporting the vast consumer electronics industry have largely vacated. The Advanced Composite Structures Program is aimed at attracting students to research in composite structures and composite mechanics. The Air Force Research in Aircraft Propulsion Technology Program (AFRAPT) has the objective of attracting students to research in aircraft propulsion technology. The Manufacturing Sciences Program has the objective of attracting students to research in manufacturing techniques associated with aerospace vehicle assemblies. Total funding for these four programs increased from $2.5 million in FY 1982 to $44.4 million in FY 1985.

AFOSR supports two programs which being university faculty members and graduate students into Air Force laboratories for ten weeks during the summer. The Summer Faculty Research Program (SFRP) is designated to develop the basis for continuing research of interest to the Air Force at the faculty member's institution. In addition to the ten week summer research program, funding is also provided to allow about 50 percent of the researchers (on a competitive basis) to continue the research at his or her home institution. The Graduate Student Summer Support Program (GSSSP) allows outstanding graduate students to spend ten weeks at an Air Force laboratory conducting research while accompanying faculty members selected under the SFRP. Funding for these programs increased from $1.5 million in FY 1982 to $4.4 million in FY 1985.

The Air Force supports several programs which allow postdoctoral scientists and engineers to spend a year conducting research at Air Force laboratories on problems of their own choice that are compatible with research interests of the sponsoring laboratories. The Air Force Systems Command/National Research Council Resident Research Associateship Program and the University Resident Research Program are supported by AFOSR but with researchers placed at various participating laboratories. The Air Force Geophysics Laboratory and the Air Force Weapons Laboratory also support, respectively, the Geophysics Scholar Program and the Weapons Laboratory Scholar Program within their own laboratories. Total funding for these programs increased from $1.6 million in FY 1982 to $2.9 million in FY 1985.

AFOSR is engaged in special initiative utilizing workshops and focused advertising to make Historically Black Colleges (HBCs) aware of opportunities in Air Force research and development, and to recruit faculty members and graduate students from HBCs for participation in the SFRP and GSSSP. In addition, under a grant from AFOSR, the Tuskegee Institute is conducting a summer research appenticeship program for minority high school students.

# CHAPTER X

# DOD RESEARCH PERFORMED IN UNIVERSITIES AND NATIONAL SECURITY CONTROLS*

## A. Introduction

Debate over the proper extent of national security controls on Department of Defense (DOD) sponsored research at colleges and universities is not new. This chapter presents a review of the various mechanisms the Federal Government has utilized since the beginning of World War I in order to restrict the communication of and access to, science and technological information for national security reasons.

The chapter notes that after World War II, the Federal Government, for the first time, placed restraints on exports from the United States to certain countries that were not at war for reasons of national security. Passage of the Export Control Act and certain provisions contained in the Atomic Energy Act of 1949, demonstrated the Federal Government's resolve to prevent the unauthorized dissemination of science and technology information to the Nation's enemies.

A thaw in the cold war in the 1960s and the early 1970s led to an easing of export restrictions on international trade and greater scientific cooperation between the United States and the Soviet Union and its Warsaw Pact allies. However, during the final months of the Carter Administration increasing U.S.-Soviet tensions resulted in the curtailment of various cooperative activities by the two super powers, including scientific and technological exchanges. The Reagan Administration stepped up enforcement of laws restricting the availability and communication of information or goods of possible value to a hostile nation, primarily the Soviet Union.

For example, the chapter notes that for the first time since the 1950s, the United States, primarily through the DOD and the Department of Commerce, utilized a number of legislative and executive authorities to tighten control over the flow of critical scientific and technological information to the Soviet Union and its allies.

The chapter concludes with some discussion of how attempts to curb the flow of science and technological information have affected the various research activities at the nation's universities. As the chapter indicates, because of recent Federal Government attempts to tighten controls on scientific and technological information, there is concern in the academic community that DOD-supported research, especially SDI work, may eventually be classified. Some academics point to DOD's attempt to control which foreign students will have access to NSF supported supercomputers, as a sign of growing DOD control of university-based research.

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At the same time, the chapter points out, representatives from DOD have stated that the benefits of open publication and dissemination of basic research findings outweigh the risks associated with the prevention of their publication. Other chapters have recounted the long, mutually beneficial relationship that has developed between DOD and the academic science community, a relationship that has always had a component of national security restriction on public revelation of selected work.

## B. Background

From the earliest days of the Republic until the dawn of modern global war, American Federal policy has largely been supportive of the tradition in scientific research, particularly campus-based studies, of open communication, free exchange of information, and wide publication.[1] The entry of the United States into World War I, however, brought a variety of restrictions.[2] University scientists, like any other American citizen publishing information related to the war effort, were subject to censorship and prosecution for loyalty-security breaches.[3] Scientists also were prohibited from engaging in any export or "trade" with an enemy without a license from the President.[4] And scientists seeking a patent might be ordered to keep their invention secret until the end of the war, at which time the application would be granted. Normal publication during the hostilities was deemed to be "detrimental to the public safety or defense, or may assist the enemy or endanger the successful prosecution of the war." [5] In addition to these controls, the National Research Council of the National Academy of Sciences apparently played an important role in identifying, encouraging, and coordinating militarily significant scientific research, and in educating and otherwise apprising university scientists of the military importance and sensitivity of their studies and findings.[6]

On the eve of U.S. entry into World War II, various restrictions affecting traditional open scientific communication were activated. In 1940, Congress broadened the Patent Commissioner's discretion to order an invention to be kept secret by deleting the requirement that the country be at war and by allowing the Commissioner to withhold the grant of a patent "for such period or periods as in his opinion the national interest requires." [7] This authority lasted until the end of the war.[8]

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[1] Dupree, Hunter A. Science in the Federal Government. Cambridge, Harvard University Press, 1957. pp. 372-373.

[2] Murphy, Paul L. World War I and the Origins of Civil Liberties in the United States. New York, W. W. Norton Company, 1979.

[3] Among the more formidable statutes limiting freedom of expression during the period of U.S. involvement in World War I were the Espionage Act (40 Stat. 217), the Trading with the Enemy Act (40 Stat. 411), and the Sedition Act (40 Stat. 553).

[4] See 40 Stat. 411.

[5] See 40 Stat. 394; 40 Stat. 411 at 422.

[6] Willoughby, William Franklin. Government Organization in War Time and After. New York, D. Appleton, 1919. pp. 22-30.

[7] See 54 Stat. 710.

[8] Ibid., p. 370.

The First War Powers Act, signed into law 11 days after the attack on Pearl Harbor, conferred on the President authority to censor all communications with foreign countries.[9] The domestic press and radio were treated on a strictly voluntary and extra-legal basis under a censorship code issued by the Office of Censorship.[10] A similar arrangement was in operation within the U.S. scientific community well before the declaration of war.

Growing concern among some scientists about the open publication of scientific information of potential military value, particularly in the area of uranium fission, prompted the National Research Council to form a special control committee in April 1940.[11] Through the voluntary cooperation of the editors of various professional scientific journals, the panel or one of its subcommittees reviewed manuscripts and research papers for possible vital defense information. Judgments were offered as to the advisability of publication. This reivew system was nominally in effect until June 1945, but the absorption of many scientists into Government-sponsored war work of one kind or another greatly reduced the production of papers for submissions.[12] Indeed, it appears the Government possessed considerable indirect regulatory power over the open communication of scientific information as a consequence of its large-scale employment of scientists or sponsorship of their research during the war years.

There were two other noteworthy developments during this period. Security classification procedures, which previously had been mandated largely through armed forces regulations and directives, attained a presidential character in 1940 when the first executive order in this policy areas was issued.[13] E.O. 8381 gave civilian employees of certain Federal agencies authority to designate some types of information—such as Government-sponsored scientific research—as officially secret in order to safeguard national defense interests.

Loyalty-security practices became more formal and sophisticated during this era as well. A great many university scientists were introduced to such a program when they joined the Manhattan Project. Because the operation was under the supervision of the Army Corps of Engineers, prevailing military wartime security requirements were applicable. Some special protective procedures also were used. Foremost among these, in the view of project manager General Leslie R. Groves, was compartmentalization of knowledge: ". . . each man should know everything he needed to know to do his job and nothing else." [14] In addition, code names were used to mask certain sensitive and secret matters; both official and personal correspondence was monitored for indiscretions; "loose-talk" cases were investigated and acted upon; project personnel were scrutinized and required to meet established loyalty and integrity requirements; a vigorous security education program was maintained; public relations efforts were made to obtain the cooperation of newspapers and the populace of communities located adjacent to Project plant sites; and a censorship-review program was created to limit media reports relating to the existence of the Manhattan Project and its work.

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[9] Ibid., 838.

[10] U.S. Office of Censorship. A Report on the Office of Censorhsip. Washington, U.S. Govt. Print. Off., 1945; also see Robert E. Summers, comp. Wartime Censorship of Press and Radio. New York, H. H. Wilson Company, 1942.

[11] Weart, Spencer R. Scientists with a Secret. Physics Today, v. 29, Feb. 1976: p. 23–30.

[12] Brown, Anthony Cave and Charles B. MacDonald, eds. The Secret History of the Atomic Bomb. New York, The Dial Press-James Wade, 1977. p. 30–31.

[13] E.O. 8381, 3 C.F.R. 1938–1943 Comp. p. 634; for a general history of security classification policy, see Harold C. Relyea. The Presidency and the People's Right to Know. In Harold C. Relyea, ed. The Presidency and Information Policy. New York, Center for the Study of the Presidency, 1981. p. 9–29.

[14] Groves, Leslie R. Now It Can Be Told: The Story of the Manhattan Project. New York, Harper and Brothers, 1962. p. 140.

Personnel having access to any official secrets of the Project were subject to a background investigation to establish their loyalty, integrity, and discretion. Approved individuals were informed of the penalties for disclosing classified information improperly and "then required to read and sign either the Espionage Act or a special secrecy agreement as a condition of employment." [15] By August 1945, some 400,000 Manhattan Project employees reportedly had been investigated and approximately 600 companies involved in the Project had been cleared. Business firms received security approvals if Army intelligence files, a Dun and Bradstreet credit report, and agency checks of key personnel revealed no adverse findings.[16]

In 1946, although many scientists remained dissatisfied with the resulting legislation after their vigorous and concerted efforts to change it,[17] the Atomic Energy Act was signed into law.[18] It provided the Federal Government a monopoly over all aspects of atomic energy research, development, and production. The statute also set rigid security limitations on the dissemination of what was termed "Restricted Data," which broadly and generally embraced all information concerning atomic weapons and fissionable material. Although the atomic energy program was largely overhauled in 1954 to allow industrial participation in nuclear power applications,[19] the Resticted Data controls of the 1946 Act were continued. Shortly after the original law was enacted, the noted First Amendment lawyer Zechariah Chafee, Jr., commented: "The controversy over atomic bomb control shows how the claim of military security may possibly be used to hamper civilians in proper scientific activity, the progress of which depends on public communication in lectures and learned periodicals." [20] Brisk technical progress in nuclear energy during the period 1945–1965 continued nevertheless.

A year later, as the dimensions of the Cold War took shape, President Harry Truman issued an executive order creating the first systematic all-inclusive Federal personnel loyalty-security screening program.[21] In requiring a loyalty investigation for all applicants for employment and all current civil servants, the basic standard to be applied was whether, on all the evidence, "reasonable grounds exist for the belief that the person involved is disloyal to the Government of the United States," or, as modified in 1951, "reasonable doubt as to the loyalty of the person involved to the Government of the United States." [22] Among the considerations to be made in determining loyalty were "intentional, unauthorized disclosure of confidential documents of information" and performing duties or acting "so as to serve the interest of another Government in preference to the interests of the United States." In the atmosphere of Cold War, few scientists in Goverment, or thinking of an association with the Government, wished to engage in professional communication which might be questioned on these terms. In addition, caution was advisable in becoming involved in any way with organizations, groups, or movements critical of Government policy or American society.[23]

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[15] Brown and MacDonald. The Secret Story of the Atomic Bomb. p. 204.

[16] Ibid., p. 201.

[17] Hewlett, Richard G. and Oscar E. Anderson, Jr. A History of the United States Atomic Energy Commission: The New World, 1939/1946. University Park, The Pennsylvania State University Press, 1962. p. 408–530.

[18] 60 Stat. 755.

[19] 68 Stat. 919.

[20] Chafee, Zechariah, Jr. Freedom of the Presss in the United States. Chicago, University of Chicago Press, 1947. p. 29.

[21] E.O. 9835, 3 C.F.R. 1943-1948 Comp. p. 627; also see Eleanor Bontecou. The Federal Loyalty-Security Program. Ithaca Cornell University Press, 1953.

President Eisenhower issued a more comprehensive order in 1953, making agency heads responsible for "establishing and maintaining . . . an effective program to ensure that the employment and retention in employment of any civilian officer or employee . . . is clearly consistent with the interests of national security." [24] Three years later, however, this directive was drastically curtailed by the Supreme Court in a decision which effectively made it inapplicable to most Federal employees.[25]

Until the Cold War, the Federal Government traditionally had restricted exports only in times of war or special emergencies. The policy of exerting rigid peacetime restraints over United States exports to certain countries who themselves were not at war with U.S. allies, for reasons of national security began with the Export Control Act of 1949.[26] While the purpose of the law was to require proper licensing for regulated goods to be shipped to particular foreign destinations, the authority of the statute affected scientists in an unusual way. During the early 1950s, American scientists mailing unclassified scientific information to friends and colleagues abroad were required by the Department of Commerce to affix an "Export License Not Required" label on the outside of their envelopes to indicate that they were aware of export regulations and had not violated general export license requirements. This situation resulted from a claim by the Department that the Export Control Act conveyed authority to exercise discretion over the export of technical data as well as commodities and goods, with "technical data" being interpreted to include basic scientific research information.[27]

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[22] E.O. 10241, 3 C.F.R. 1949-1953 Comp. p. 749.

[23] Brown, Ralph S., Jr. Loyalty and Scurity. New Haven, Yale University Press, 1948; Walter Gellhorn. Security, Loyalty, and Science. Ithaca, Cornell University Press, 1950; Harold M. Hyman. To Try Men's Souls: Loyalty Tests in American History. Berkeley, University of California Press, 1959.

[24] E.O. 10450, 3 C.F.R. 1949-1953 Comp. p. 936.

[25] Cole V. Young, 351 U.S. 536 (1956).

[26] 63 Stat. 7.

[27] U.S. Congress. House. Committee on Goverment Operations. The Goverment's Classification of Private Ideas. H. Rept. 95-1540, 96th Cong., 2d Sess. Washington, U.S. Govt. Print. Off., 1980. p. 98-99.

These restrictions were instituted after two high-level studies at the time counseled against such an approach. In its 1947 report, the President's Scientific Research Board, chaired by John R. Steelman, concluded that Government security regulations "should be applied only when strictly necessary and then limited to specific instruments, machines or processes. They should not attempt to cover basic principles or fundamental knowledge." [28] A 1950 report on the role of the Department of State in the field of national and international science, prepared for the Department of State in the field of national and international science, prepared for the Department by Dr. Lloyd V. Berkner under the sponsorship of the National Academy of Sciences, found "ample evidence that unnecessary restrictions exist on the flow of unclassified scientific and technological information." Among other relevant conclusions, the Berkner report stated: "These restrictions are dangerous to the progress of United States science, affect adversely the conduct of foreign relations in science, and are therefore damaging to our national security." [29]

The protests of scientists prompted the House Special Subcommittee on Government Information to champion a recommendation, formally endorsed by the full committee, that the Export Control Act be amended to make it clear that "technical data" did not include scientific information of an unclassified status.[30] Although the Department of Commerce accordingly revised its regulations concerning the overseas mailing of nonclassified scientific information, this controversy did not subside until changes in the policy on exports to Communist bloc nations emerged during the 1960s, and the Export Administration Act of 1969,[31] reflecting this new position on technical data, was adopted.[32]

In 1952, a permanent statute on patent security was signed into law.[33] The Invention Secrecy Act provided that, "[w]henever the publication or disclosure of an inventory by the granting of a patent, in which the Government does not have a proprietary interest, might, in the opinion of the [Patent] Commissioner, be detrimental to the national security," he shall make the application available to certain specified defense agencies for review. In the event that one of them determines that "publication or disclosure of the invention by the granting of a patent therefore would be detrimental to the national security, . . . the Commissioner shall order that the invention be kept secret and shall withhold the grant of patent" for not more than one year, subject to a possible renewal.

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[28] President's Scientific Research Board. Science and Public Policy: Administration for Research, v. 3, Washington, May 1950. p. 85

[29] U.S. Dept. of State. International Science Policy Survey Group. Science and Foreign Relations. Washington, May 1950. p. 85.

[30] U.S. Congress. House. Committee on Government Operations. Availability of Information from Federal Departments and Agencies. H. Rept. 2947 84th Cong., 2d Sess., Washington, U.S. Govt. Print. Off., 1956. p. 92; also see U.S. Congress. House. Committee on Government Operations. Availability of Information from Federal Departments and Agencies. H. Rept. 2578, 85th Cong., 2d Sess. Washington, U.S. Govt. Print. Off., 1958. pp. 17-28.

[31] 83 Stat. 41.

[32] Berman, Harold J. and John R. Garson. United States Export Controls—Past, Present, and Future. Columbia Law Review, v. 67, May 1967. p. 791-890; U.S. Congress. Office of Technology Assessment. Technology and East-West Trade. Washington, U.S. Govt. Print. Off., 1979. pp. 112-126. Also see Kenneth W. Abbott. Linking Trade to Political Goals: Foreign Policy Export Controls in the 1970s and 1980s. Minnesota Law Review, v. 65, June 1981: pp. 739-889; John F. Murphy and Arthus T. Downey. National Security, Foreign Policy and Individual Rights: The Quandary of United States Export Controls. International and Comparative Law Quarterly, v. 30, Oct. 1981: pp. 791-834.

[33] 66 Stat. 3; 66 Stat. 792 at 805.

Almost three years later, in November 1954, Secretary of Commerce Sinclair Weeks announced that, at the direction of the President and on the recommendation of the National Security Council, he was creating an Office of Strategic Information within his department.[34] The mission of the new entity, according to the Secretary, was to work with various private sector groups "in voluntary efforts to prevent unclassified strategic data from being made available to those foreign nations which might use such data in a manner harmful to the defense interests of the United States." [35] The Office, however, was something of an anomaly. It had no legislative charter and its activities, in many regards, appeared to overlap with and duplicate certain more clearly and statutorily stated functions of other agencies. Because the concept of "strategic information" was not specifically defined, its regulatory application seemed to those affected to be of uneven impact. Nevertheless, the Office sought to correct the imbalance favoring the Communist bloc in exhanges of scientific, technical, and economic information and to alert Federal agencies as well as scientists, businesses, and the press to the dangers of indiscriminate publication of unclassified information of possible benefit to an enemy nation.

Both the journalism and science communities brought their protests against the regulatory efforts of the Office to the attention of the House Special Subcommittee on Government Information.[36] This panel concluded that the Office was redundant and served no useful purpose. When its abolition was urged, the recommendation was endorsed by the parent Committee on Government Operations in 1956.[37] In April of the following year, the House of Representatives eliminated all funds for the Office and prohibited the transfer of money from other sources for its continuation.[38] When the Senate agreed to this action, Secretary Weeks was forced to abolish the Office.[39]

## C. An Easing of Controls

The experience of World War II convinced the United States of the importance of science and technology to national security. The subsequent Cold War and growing efforts of the Soviet Union to acquire illegally Western technology reinforced this recognition. More and more contributions of science and technology became vital to the security of the United States and, therefore, as a matter of Government policy in need of protection to restrict their availability. Dr. Lloyd V. Berkner assessed the situation for a congressional subcommittee in March 1956 in the following words:

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[34] Federal Register, v. 19, Dec. 7, 1954. p. 8045-8046; also see Ibid., v. 20, Sept. 28, 1955. p. 7233.

[35] U.S. Dept. of Commerce. Office of the Secretary. Press release G-520. Washington, D.C., Nov. 5, 1954; also see James Russell Wiggins. Freedom or Secrecy. Revised edition. New York, Oxford University Press, 1964. pp. 102-103.

[36] U.S. Congress. House. Committee on Government Operations. Availability of Information from Federal Departments and Agencies. Hearings, 84th Cong., 2d Sess., Washington, U.S. Govt. Print. Off., 1956. pp. 1123-1187, 1233-1286, 1447-1521, 1639-1711.

[37] H. Rept. 2947, 84th Cong., 2d Sess., p. 91.

[38] Congressional Record, v. 103, Apr. 9, 1957. p. 5376; also see H. Rept. 2578, 85th Cong., 2d Sess., pp. 13-14.

[39] Federal Register, v. 22, July 24, 1957. p. 5876.

> . . . as society generally has become deeply dependent on technological development, so too has the military organization increased its dependence on science and technology.
>
> Initially, at least, it appeared reasonable that the military restrict the exchange of ideas having military implications on the ground that to permit the free flow in information would hand the enemy our developmental achievements "on a platter."
>
> In the modern world, however, all the important ideas of science have military implication and, under our present policies, must therefore fall inevitably under the cloak of military secrecy.[40]

Many scientists, for reasons of principle, function, and convenience were not happy with this state of affairs. For them, the free dissemination of information and open discussion were, and remain, essential parts of the scientific process. Ideally, they maintained, findings should be publicly and generally available, and subject to criticism, improvement, and, if warranted, rejection. Inevitably, research and, consequently, scientific progress, suffer from the imposition of extreme secrecy. The condition of science in the Soviet Union is sometimes cited as speaking to this point. It also was stated by Dr. Vannevar Bush in his 1945 report to the President concerning a program for postwar scientific enterprise. It was his observation that,

> A broad dissemination of scientific information upon which further advances can readily be made furnishes a sounder foundation for our national security than a policy of restriction which would impede our own progress although imposed in the hope that possible enemies would not catch up with us.[41]

In his 1956 congressional testimony, Dr. Berkner was much in agreement with Bush's perception. He offered the view that, since the end of World War II, "we have steadily lost ground relative to our competitors until now there is serious question whether the United States actually retains leadership in certain critically important fields of military technology." This situation has developed, he said, primarily because of "the slowing down of our technological achievement." In his opinion, "an important aspect of this loss of supremacy in certain fields of technology stems from our present widespread practice of technological secrecy, consequent clearance and security practices, compartmentalization of science and technology, and restrictive practices exercised over science and scientists."[42] Others contend that Soviet gains in military technology stem from their State-controlled priority allocation of resource to military goals and from successful acquisition of Western technology. Spokesmen for a strong security classification policy saw little evidence that U.S. scientific progress had been slowed, noting that the U.S. science community was the world's most dynamic.

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[40] U.S. Congress. House. Committee on Government Operations. Availability of Information from Federal Departments and Agencies. Hearings, 84th Cong., 2d Sess. p. 756.

[41] Bush, Vannevar. Science—The Endless Frontier. Washington, National Science Foundation, 1980; originally published 1945. p. 29.

[42] U.S. Congress. House. Committee on Government Operations. Availability of Information from Federal Departments and Agencies. Hearings, 84th Cong., 2d Sess., p. 751.

Releif from the kinds of secrecy and security controls that Dr. Berkner and some others were criticizing in the late 1950s came in the 1960s largely because of international trade and foreign policies of greater cooperation with the Soviet Union and its Warsaw Pact allies.[43] Among the diplomatic and commercial ventures pursued during the 1970s with a view to easing tensions between the United States and Communist bloc nations were various exchanges of scientific personnel and sharing of technological knowledge. As the seventies passed into history, however, America saw the advantages of detente (including scientific exchange) as increasingly one-sided, favoring the Soviets. Soviet military equipment, advisers, and Cuban troops were landed in Angola and later in Ethiopia in support of governmental efforts to suppress rebellion. Despite condemnations and protests from both Congress and President Carter, the Soviet Union vigorously pursued the prosecutions and punishments of prominent dissident intellectuals. The United States next discovered that up to 209 advanced Mig-23 jets had been based in Cuba. Some months later it was learned that a Soviet combat brigade was stationed in Cuba as well. And in December 1979, the era of "detente" came to an abrupt end when the Soviet Union invaded Afghanistan.

During the final months of the Carter Administration, renewed U.S.-Soviet tensions prompted the curtailment of various cooperative activities by the two superpowers, including a number of scientific and technological exchanges. With the arrival of the Reagan Administration, both American domestic and foreign policy assumed a stronger anti-Communist attitude, manifesting itself in increased defense spending and national security preparations, more vigorous enforcement of laws restricting the availability and communication of information or goods of possible value to a hostile nation, and pursuit of new authority for more strictly controlling the unauthorized acquisition of American technological commodities and scientific knowledge by foreign countries. While justified in terms of "national security," there can be, and apparently are, fundamentally different interpretations of this concept.

## D. The Concept of National Security

Although the precise origins of the terms are unceretain, "national security" had some currency 200 years ago when, around 1790, Yale University students reportedly debated the question, "Does National Security depend on fostering Domestic Industries?"[44] A perusal of the Federal statutes, however, suggests that the phrase gained policy popularity during the period of U.S. involvement in World War I. But its appearance in laws enacted after 1919 tapered off over the next decade. In the aftermath of

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[43] U.S. Office of Technology Assessment. Technology and East-West Trade. pp. 112-126.

[44] Rostow, W.W. How It All Began. New York, McGraw-Hill Book Company, 1975. p. 191.

World War II, "national security" became prominent again in official pronouncements, presidential directives, statutes, and agency regulations. The adaptive nature of the term was well appreciated by 1949 when Sidney W. Souers, then Executive Secretary of the National Security Council, described it as "a point of view rather than a distinct area of governmental responsibility." [45]

A few years ago, a computer search indicated that "national security" appeared about 390 times in the 1970 edition of the U.S. Code, with additional inclusions in the uncodified statutes. A little more than 100 of these entries pertained to Government institutions, such as the National Security Agency or the National Security Council. Another score were section headings or cross-references, and an additional score explicitly referred to the National Security Act. Slightly more than 240 of the remaining citations, however, were descriptions of a policy condition, often granting the President considerable discretionary authority to take action "for reasons of national security," "in the interest of national security," or "for purposes of national security." [46] Some of these references, of course, appeared in laws which provide authority for controlling certain aspects of scientific study, teaching, and communication. However, "national security" is not defined in statutory law.

Dr. Vannevar Bush suggested in his 1945 report to the President that "national security" can be viewed as resulting from achievement in science, not from concealment which can frustrate scientific enterprise. Clearly, "national security" and "science" are not antagonistic to one another. In the past, scientists and government leaders have demonstrated a broad appreciation of the national security concept, including not only military applications and preparations, but also economic, cultural, and psychological considerations. Many within the governmental, economic, and scientific communities have noted that national security, in its most meaningful context, is not defined in terms of military preparedness alone.

Recent changes in policy became apparent to scientists when Federal officials began seeking to limit certain communications concerning campus scientific research, selected presentations or participants at scientific professional conferences, and the teaching of some scientific subject matter to certain foreign students. In general, the rationale for these actions have been that some particular kind of information, considered sensitive in a national security context, was being improperly imparted and, in order to prevent this conveyance, the Government was exercising its regulatory powers. The principal authorities relied upon in these efforts have been export control laws—the Export Administration Act and its regulations,[47] and the Arms Export Control Act [48] and its International Traffic in Arms Regulations [49]—and Government research contract prerogatives. Security classification powers, the Atomic Energy Act, and the Invention Secrecy Act have been invoked in this regard as well.

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[45] Souers, Sidney W. Policy Formulation for National Security. American Poliical Science Review, 43, June 1949: 535.

[46] U.S. Congress. Senate. Committee on Governmental Affairs. Emergency Powers of the District of Columbia. Hearing, 96th Cong., 2d Sess., Washington, U.S. Govt. Print. Off., 1980. p. 18.

[47] 15 C.F.R. 368-399.

[48] 22 U.S.C. 2751-2794.

[49] 22 C.F.R. 121-130.

## E. The Contemporary Setting

Since the Soviet invasion of Afghanistan in December 1979, which effectively ended "detente," various actions by the Federal Government and official statements have reflected a growing anxiety about the unauthorized transfer of scientific and technological information from the United States to the Soviet Union and its Warsaw Pact allies. Among the first to be affected by this changed policy environment were campus-based scientists performing independent research as well as government-supported studies. Those within the university community have especially high expectations concerning the unfettered flow of information within the country and the larger free world. There is thought to be entitlement to something called "academic freedom" and, some would argue, "scientific freedom." On the first point, Justice Felix Frankfurter wrote that there are "four 'essential freedoms' of a university—to determine for itself on academic grounds who may teach, what may be taught, how it shall be taught, and who may be admitted to study." [50] As to the latter consideration, the Committee on Science in the Promotion of Human Welfare, chartered by the American Association for the Advancement of Science (AAAS), offered the following comment a few years ago:

> Free dissemination of information and open discussion is an essential part of the scientific process. Each separate study of nature yields an approximate result and inevitably contains some errors and omissions. Science gets at the truth by a continuous process of self-examination which remedies omissions and corrects errors. This process requires free disclosure of results, general dissemination of findings, interpretations, conclusions,and widespread verification and criticism of results and conclusions.[51]

For campus scientists and intellectuals much in the way of professional recognition and pecuniary reward also presupposes unfettered communication. With the end of "detente," campus scientists soon became aware of some shifting of attitude toward scientific communication and the implications for both academic and scientific freedom. On the rhetorical level, in the autumn of 1981, the Department of Defense published its initial version of a booklet entitled *Soviet Military Power.* Acknowledged to be "a distillation of briefings provided to the NATO Ministers of Defense," the document described "the totality of the Soviet military buildup." [52] A chapter on the Soviet quest for technological superiority offered the following comment in a section concerning technology transfer:

> In addition to the acquisition of Western industrial plants and equipment, the decade of the 1970s has also

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[50] Sweezy v. New Hampshire, 354 U.S. 234 at 255 (1957).

[51] American Association for the Advancement of Science. Committee on Science in the Promotion of Human Welfare. The Integrity of Science. American Scientist, v. 53, June 1965: 177.

[52] U.S. Dept. of Defense. Soviet Military Power. Washington, D.C., [Sept.] 1981. p. 5.

> witnessed greatly expanded contact between the Free World and Soviet scientists and engineers. The scope and depth of their interest in the advanced and emerging technologies is exemplified by the exchange agreements that the Soviet Union has negotiated with the United States since 1972.[53]

Similarly, student and scholar exchanges, interchanges between members of the United States and Soviet Academies of Science, American scientific conferences and symposia, the availability of research reports from the National Technical Information Service, and open professional literature in the United States were all cited in this regard. The section then concluded with the following assessment: "The Soviets are seeking Western technology and equipment by any and all means in their quest for technological superiority." [54]

That October, William D. Carey, executive officer of AAAS and publisher of *Science*, wrote to Deputy Secretary of Defense Frank Carlucci, saying he was "dismayed to find the Defense Department indicting inter-Academy exchanges, student exchanges, scientific conferences and symposia, and the entire 'professional and open literature' as inherently adverse to U.S. military security interest." He concluded by indicating he was "exercised by the position taken by the Defense Department in *Soviet Military Power*" and added:

> In particular, that position strikes in a deadly way at the dependence of scientific progress on open communication and shared information. Our own military power will be diminished, not enhanced, if the wellheads of scientific communication are sealed and new knowledge confined in silos of secrecy and prior restraint.

In reply, Deputy Secretary Carlucci wrote:

> Be assured the DOD is well aware of how scientific practice is conducted and fully recognizes the importance of unimpaired scientific communications to the mutual benefit of all parties concerned. In our considered view, however, the exchanges to date, in the main, have not been reciprocal. Rather, it is quite apparent the Soviets exploit scientific exchanges as well as a variety of other means in a highly orchestrated, centrally directed effort aimed at gathering the technical information required to enhance their military posture.

After providing various examples which, in his view, "indicate the basis of our concern," he concluded in the following words:

> The Department of Defense favors scientific, technical, and educational exchanges and the free exchange of ideas in basic and fundamental science. However, since the military posture of this Nation relies so heavily on its technical leadership, the Defense Department views with alarm the blatant and persistent attempts, some of which have

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[53] American Association for the Advancement of Science. Committee on Science in the Promotion of Human Welfare. The Integrity of Science. American Scientist, v. 53, June 1965: p. 177.

[54] Ibid. pp. 80–81.

> just been described, to siphon away our militarily related critical technologies. I note this is precisely your point when you state 'nobody is arguing that the exchanges should involve security-related fields of science.' By the very nature of our open and free society, we recognize that we will never be able to halt fully the flow of militarily critical technology to the Soviet Union. Nevertheless, we believe that it is possible to inhibit this flow without infringing upon legitimate scientific discourse.[55]

The technology leakage issue was not an isolated concern of the Department of Defense. Attorney General William French Smith, speaking before the World Affairs Council on December 18, 1981, in Los Angeles, delivered a major policy address on attempts to counter Soviet espionage in the United States.[56] During the course of his remarks, the Attorney General stated that "hostile intelligence services have placed a high priority on scientific and technical information, much of which is unclassified proprietary data." A growing number of foreign intelligence agents, operating within the country under a variety of guises, "befriend employees in the United States, request innocuous information on various pretexts with nominal reimbursement, and finally attempt to obtain sensitive information in return for substantial cash payments." American businessmen "traveling in the Soviet bloc are lured into compromising situations and then blackmailed into providing information and services." High technology items "that cannot legally be exported to the Soviet bloc are frequently sent to 'front' corporations in Western Europe and then transshipped to the ultimate destination." The Attorney General assured his audience that "the Justice Department is committed to vigorous enforcement of national security legislation, including laws prohibiting unlawful export of advanced technology and munitions."

Early in January 1982, CIA Deputy Director Bobby R. Inman, speaking as a panelist at the AAAS annual meeting in Washington, suggested that "potential balance between national security and science may lie in an arrangement to include in the peer review process—prior to the start of research and prior to publication—the question of potential harm to the Nation." As director of the National Security Agency, Admiral Inman had prompted the American Council on Education to form a Public Cryptography Study Group which subsequently recommended a voluntary system for the prepublication review of manuscripts on cryptography. He seemed to be advocating the creation of a similar review arrangement, embracing not only prepublication review, but also the initiation of research as well, for various areas of scientific study. Examples which he suggested included computer hardware and software, electronic gear and techniques, lasers, crop projections, and manufacturing processes. If scientists did not cooperate in keeping certain of their research information safeguard voluntarily, Inman warned the AAAAs audience, public outrage over the resulting "hemorrhage of the country's technology" could well result in law restricting the publication of scientific work that the Federal Government considered "sensitive" on national security grounds.[57]

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[55] For the full text of both letters, see Science, v. 215, Jan. 8, 1982. pp. 139-141.

[56] For excerpts from the prepared text of the Attorney General's speech, see New York Times, Dec. 19, 1981: 32.

Also during January, in a column appearing the Wall Street Journal, Secretary of Defense Caspar W. Weinberger advised readers "that the Soviets have organized a massive, systematic effort to get advanced technology from the West. The purpose of this is to support military buildup." [58] The essay responded to revelation of a widespread organization directed at specific firms, universities, and research institutes in pursuit of specific technologies; Britain and France expelled hundreds of Soviet agents found to be engaged in this enterprise. After indicating that the Reagan Administration would seek to tighten international controls on the availability of technology through the Coordinating Committee for Multilateral Export Controls (COCOM), which was scheduled to meet in Paris the following month, he urged industry, industrial associations, and businessmen to make efforts voluntarily to better protect their technology and manufacturing how-how from acquisition by the Soviets.[59]

Before the end of the month, in its advisory capacity to the Secretary of Defense, the Defense Science Board Task Force on University Responsiveness to National Security Requirements issued a report which found, among other conclusions, that "Certain specific areas of university research, especially those conducted under DOD contract, are sensitive from an export control point-of-view." [60] The report also made the following charge: "Numerous advances in Soviet military weapon systems are directly traceable to technology transfers that occurred as a result of Soviet and Warsaw Pact student and scientific exchanges and their attendance at international scientific symposia held in the United States." [61]

Accordingly, reinterpretation of Federal regulations governing exports by university researchers, said the report, "is required" and consistent guidelines limiting distribution of certain sensitive, nonclassified scientific information were recommended.[62] These controls, it was proposed, would be written into all research contracts funded by the Department of Defense, and some of those funded by other Federal entities, and would provide guidance for certain privately funded research contracts.[63] Guidelines would be formulated "with the help of the universities" [64] and would not be "overly restrictive" or "inhibit the legitimate flow of scientific information." [65]

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[57] For the prepared text of Admiral Inman's remarks, see Harold C. Relyea, ed. Striking A Balance: National Security and Scientific Freedom—First Discussions. Washington, American Association for the Advancement of Science, 1985. p. 51-55.

[58] Wall Street Journal, Jan. 12, 1982: 32.

[59] On the origins and operations of the Coordinating Committee for Multilateral Export Controls, see U.S. Office of Technology Assessment. Technology and East-West Trade. pp. 153-170.

[60] U.S. Dept. of Defense. Office of the Under Secretary of Defense for Research and Engineering. Report of the Defense Science Board Task Force on University Responsiveness to National Security Requirements. Washington, DC, Jan. 1982. pp. 5-4. [Note: In these double figure pagination citations, the first number refers to the chapter in which the page appears; the second number pertains to the sequential position of a page within a chapter.]

[61] Ibid., pp. 4-6, 4-7.

[62] Ibid., p. 5-4.

[63] Ibid., pp. 4-7, 4-9.

[64] Ibid., p. 5-4.

[65] Ibid., p. x.

Several weeks later, in March, CIA Director William J. Casey gave his view of the technology transfer situation during a U.S. News and World Report interview, saying:

> We have determined that the Soviet strategic advance depends on Western technology to a far greater degree than anybody ever dreamed of. It just doesn't make any sense for us to spend additional billions of dollars to protect ourselves against the capabilities that the Soviets have developed largely by virtue of having pretty much of a free ride on our R&D. They use every method you can imagine—purchase, legal and illegal; theft; bribery; espionage; scientific exchange; study of trade press; and invoking the Freedom of Information Act—to get to this information.[66]

The following month, the Central Intelligence Agency released a report entitled *Soviet Acquisition of Western Technology* describing "the Soviet program to acquire U.S. and Western technology, the acquisition mechanisms used, the spectrum of Western acquisitions that have contributed to Soviet military might, the projected Soviet priority needs for Western technology, and the problems of effectively stemming the transfer of Western technology that could someday find application in weapons used to threaten the West." The general thrust of the report is conveyed in the following comment:

> The Soviets and their Warsaw Pact allies have obtained vast amounts of militarily significant Western technology and equipment through legal and illegal means. They have succeeded in acquiring the most advanced Western technology by using, in part, their scientific and technological agreements with the West to facilitate access to the new technologies that are emerging from the Free World's applied scientific research efforts; by spending their scarce hard currency to illegally purchase controlled equipment, as well as to legally purchase uncontrolled advanced Western technologies having militarily-industrial applications; and by tasking their intelligence services to acquire illegally those U.S. and Western technologies that are classified and export controlled.[67]

Paralleling these official pronouncements about technology transfer were certain Government actions to directly control scientific communication. Efforts to regulate the communication of supposedly sensitive scientific information by professional societies in their publications or at their conferences began around February 1980. At that time, the Department of Commerce informed American Vacuum Society organizers of a small international meeting on magnetic bubble memory devices that the presence of certain foreign nationals at the gathering subjected the scheduled proceedings to compliance with export requirements. In order to avoid possible penalties for failure to comply with export regulations, the sponsors of the conference rescinded the invitations that had been sent to attendees coming from Hungary, Poland, and the U.S.S.R. Scientists from the People's Republic of China, who were already en route, were permitted to attend the meetings after signing an agreement not to "re-export" what they learned to any nationals from 18 named countries.[68]

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[66] The Real Soviet Threat in El Salvador—and Beyond. U.S. News and World Report, v. 92, Mar. 8, 1982: 25.

[67] [U.S. Central Intelligence Agency.] Soviet Acquisition of Western World Report, v. 92, Mar. 8, 1982. p. 25.

In April 1984, the AAAS Committee on Scientific Freedom and Responsibility released a compilation documenting this and a dozen subsequent incidents involving professional societies. In one case—the Twenty-Sixth Annual International Technical Symposium of the Society of Photo-Optical Instrumentation Engineers--more than 100 technical papers scheduled for presentation were withdrawn at DOD insistence. Other such incidents have been reported since the issuance of the AAAS compilation.[69]

While this Government intervention was of great concern to some scientists, it appears to have stimulated some cooperative effect. In the spring of 1984, for example, individuals attending the Twenty-Fifth Structures, Structural Dynamics and Materials Conference found that two of its sessions were closed to foreigners. The conference program explained that export regulations required this limitation and that those seeking admission to the restricted meetings would be required to document their citizenship. This self-censorship occurred even though one of the sponsors of the gathering, the American Institute of Aeronautics and Astronautics, has a policy of keeping such proceedings unrestricted if at all possible. Defense Week commented on the matter saying: "Never before have organizers volunteered to close a meeting unless it was jointly sponsored by the Federal Government." [70] Perhaps, in this case, official intervention was anticipated, and perhaps other conference organizers will feel compelled to follow suit.[71]

## F. CONTROLLING OPEN COMMUNICATION OF SCIENTIFIC RESEARCH

The academic community soon became more directly aware of the Government's new national security concerns about the open communication of scientific research. In early 1981, the Department of State informed Cornell University that a Hungarian engineer, scheduled to visit the campus to study electronics, would have to be limited to classroom pursuits, could not participate in any private seminars or discussion groups, and would be prohibited from receiving prepublication copies of research papers. In view of these conditions, the visit was cancelled. Such visa conditioning, however, has continued to be a matter of high controversy.[72]

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[68] Wade, Nicholas Science Meeting Catch the U.S.-Soviet Chill. Science, v. 207, Mar. 7, 1980: 1056, 1058; also see H. Rept. 96-1540, 96th Cong., 2d sess. Op. 103-104.

[69] American Association for the Advancement of Science. Committee on Scientific Freedom and Responsibility. National Security and Scientific Communication Chronology, Washington, D.C., Apr. 1984. Also see, Mitchel B. Wallerstein. Scientific Communication and National Security in 1984. Science, v. 224, May 4, 1984: 460-466; Eliot Marshall. Do Seminars leak Navy Secrets? Science, v. 224, June 29, 1984: 1409; David Burnham. Pentagon Acts to Curb Science Parley Papers.

[70] AIAA Feels Chilling Effect of DOD Censors. Defense Week, v. 5, May 7, 1984: 6.

[71] Park, Robert. L. Intimidation Leads to Self-Censorship in Science. Bulletin of the Atomic Scientists, v. 41, Mar. 1985: 22-25.

In the autumn of 1981, the Department of State began asking academic officials at various major universities to cooperate in prohibiting visiting students from the People's Republic of China from engaging in research and studies in certain scientific and technological areas that the Department regarded as being subject to export restrictions. Many campus administrators declined to engage in such policy actions. The President of the University of Minnesota, C. Peter Magrath, for example, responded in a letter which, in part said: "Our mission is teaching, research and public service and neither our faculty nor our administrators were hired to implement Government security actions." [73] Nonetheless, while such a stand is consistent with academic freedom considerations, within a few months of time, the UCLA Extension Program scheduled a short course on metal matrix composites that was available to "U.S. Citizens Only." Co-sponsored by UCLA and the Metal Matrix Composites Information Analysis Center, which is a subsidiary of the Defense Department, the course was to be held in an open, *on-campus* conference facility.

These and other national security limitations upon academic and scientific freedom have, of course, not occurred without protest. The presidents of some of the major scientific research universities—CalTech, Cornell, MIT, Minnesota, and Stanford—have been most visible in this regard. Conversely, DOD's efforts to safeguard militarily useful Government-funded science from appropriation by Communist regimes have also received the support of various academic groups. Not long ago, Peter Magrath of the University of Minnesota told a House subcommittee that he knew of five university presidents who had received warnings of citizen civil actions from a private foundation. "The foundation promised to sponsor adverse shareholder resolutions at corporate and philanthropic meetings," he said, "because it determined that resistance to intrusive [national security] regulations was itself a threat to national security." [74]

Some professional organizations—notably, the American Association for the Advancement of Science, the Association of American Universities, the American Physical Society, and the Institute of Electrical and Electronic Engineers—have expressed their disapproval of these control efforts. The National Academy of Sciences created a Panel on Scientific Communication and National Security to examine this whole issue of new restrictions. Chaired by Dr. Dale R. Corson, President emeritus of Cornell University, and given full support by the Department of Defense and the Federal intelligence community, this body issued its final report of findings and recommendation in September 1982. Although the report conceded that there had been "a substantial transfer of U.S. technology—much of it directly relevant to military systems—to the Soviet Union from diverse sources," it found "that universities and open scientific communication have been the source of very little of this technology transfer problem." [75]

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[72] Kolata, Gina Bari. Attempts to Safeguard Technology Draw Fire. Science, v. 212, May 1, 1981: pp. 523–524, 526. Also generally, see American Civil Liberties Union. Free Speech, 1984. New York, New York, 1984. pp. 628–629.

[73] Crossettee, Barbara. State Department is Asking Colleges to Curb Research by Chinese. New York Times, Nov. 27, 1981: A1–A15.

[74] U.S. Congress. House. Committee on the Judiciary. 1984: Civil Liberties and National Security State. Hearings, 98th Cong., 1st and 2d Sess., Washington, U.S. Govt. Print. Off., 1984. p. 61.

A short time later, on December 23, 1982, President Reagan signed National Security Study Directive 14-82 establishing an interagency group, chaired by the Office of Science and Technology Policy, to "review the issue of protecting sensitive, but unclassified scientific research information, taking into account the recommendations made by" the Corson panel. The interagency group was tasked with preparing its report no later than March 1, 1983, for consideration by the National Security Council. This deadline was missed and it was never clear if the interagency group actually produced a formal report. Nonetheless, on September 25, 1985, the President signed National Security Decision Directive 189 setting a National Policy on the Transfer of Scientific Technical and Engineering Information and otherwise responding to the Corson report. It declared:

> It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. It is also the policy of this Administration that, where the national security requires control, the mechanisms for control of information generated during federally-funded fundamental research in science, technology, and engineering at colleges, universities and laboratories is classification. Each Federal Government agency is responsible for: (a) determining whether classification is appropriate prior to the award of a research grant, contract, or cooperative agreement, and, if so, controlling the research results through standard classification procedures; (b) periodically reviewing all research grants, contracts, or cooperative agreements for potential classification. No restrictions may be placed upon the conduct or reporting of federally-funded fundamental research that has not received national security classification, except as provided in applicable U.S. statutes.[76]

While some in the scientific community hailed this policy statement because it seemingly made security classification and classification criteria the only basis for Governmental control of federally-funded fundamental research information and its communication, others noted that the final, qualifying phrase appeared suspect and contradictory. Security classification was reaffirmed as the primary control device, but the restrictive powers of "applicable U.S. statutes" were still available for use, and it was this source of regulatory authority that had been troublesome for some scientists during the past five years.

Similarly, many scientists took no great comfort from recent amendments to the Export Administration Act [77] which were supposed to provide some relief from its control of the communication of basic scientific research information.[78] The statute was amended, with the following section being added to its declaration of policy provisions:

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[75] National Academy of Sciences. Panel on Scientific Communication and National Security. Scientific Communication and National Security. Washington, National Academy Press, 1982. p. 1.

[76] National Security Decision Directive 189. National Policy on the Transfer of Scientific, Technical and Engineering Information. Washington, Sept. 21, 1985. [unpublished.]

[77] 99 Stat. 120.

> It is the policy of the United States to sustain vigorous scientific enterprise. To do so involves sustaining the ability of scientists and other scholars freely to communicate research findings, in accordance with applicable provisions of law, by means of publication, teaching, conferences and other forms of scholarly exchange.

Critics contend that the qualifying phrase "in accordance with applicable provisions of law" probably diminishes the original purpose of the section. This will occur, they hold, if it can be successfully argued that the "provisions of law" referenced in the new policy provision refers to other more restrictive regulatory authorities. It is also pointed out that other restrictive statutes could be brought to bear here as well.

Clearly there are some academic scientists that would like to witness the complete elimination of national security controls on their science and technology activities. However, most scientists have few problems with what they believe are very limited restraints on their current DOD research activities. Further, any restraints or DOD prepublication review requirements must be agreed to by the principal investigator before a DOD research contract is awarded. Defenders of the Reagan Administration policies cite the abundance, diversity, and ease of scientific interaction and publication in the United States as providing perspective on the danger of repression ascribed by some critics to its security measures. The breadth of interaction between the defense and scientific communities is also noted in this regard.

## G. IMPACTS ON COLLEGES AND UNIVERSITIES

Recent Administration attempts at selective control of the dissemination of certain scientific and technological information fall into two broad categories: those restricting the written and oral dissemination of certain scientific and technological ideas, and those restricting the access of specific foreign students and visiting scholars, primarily from the Soviet Union and its allies, to U.S. classrooms, laboratories, and professional meetings. The primary justification given for these restrictions is the need to protect dual use technologies which play an important national security role. Dual use technologies are those technologies (e.g. high-speed electronics, and computer based encryption techniques) which could have commercial as well as military applications. The Reagan Administration is concerned that the United States and its allies might lose their military advantage if they do not adequately block the intensive efforts of the Soviet Union to gain access to Western dual use science and technology.

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[78] Relyea, Harold C. Export Administration Amendments: Implications for Scientific Communication. Transnational Data Report, v. 8, no. 7, 185: 361-363.

These selective attempts to curb the flow of certain scientific and technological information have aroused some concern in the nation's universities. There is concern within the university research community that DOD-supported research, especially SDI work, may eventually be classified. Both Administration and Pentagon officials have repeatedly assured university researchers that their intent is to leave basic research, performed at colleges and universities, unclassified. This was the primary intent of National Security Decision Directive 189 (NSDD 189). Researchers have pointed out that the final phrase of NSDD 189, "except as provided in applicable U.S. statues," could be interpreted to limit the communication of findings arising from unclassified basic research. Many university researchers also doubt that the Congress intended the Export Administration Act and the Arms Export Control Act to restrict the publication and oral presentation of basic research findings.[79]

Dwight Duston, director of SDI's Innovative Science and Technology Office, has indicated that no university contracts awarded through his office have involved classified research.[80] Nevertheless, DOD officials cannot promise not to classify basic research because U.S. law allows the Government to impose classification if national security considerations warrant it. Many scientists believe that if potential applications of basic research become apparent for such programs as SDI, midstream security restrictions may be imposed. This was acknowledged by Dwight Duston, when he stated that "a university investigator's basic research for SDI could be declared classified at a latter date." [81]

Dr. Linda S. Wilson, Vice President for Research at the University of Michigan, has stated that midstream classification of an individual's research project poses difficult problems for most universities. According to Dr. Wilson, "many universities would have to terminate the SDI research agreement if classification were imposed because of their policies which require open publication of research results." [82] Such a midstream disruption would present particular hardships on graduate students working on their thesis and could interrupt the evaluation of various faculty. Some, however, doubt that such difficulties should they arise, would prove intractable.

Another area of concern is that, once an initial scope of work is agreed upon, DOD might attempt to redirect the scope of the research project. Given the nature of such programs as SDI, this might be understandable. However, Dr. Wilson indicates that, "given one of the functions of university based research . . . to serve the dual purpose of graduate education and the production of knowledge . . . such redirection could be extremely problematical." [83]

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[79] Adler, Alan. Science and Government Report, May 1, 1986: p. 5.

[80] Military Support for Research Has Not Had a Major Impact on Universities, Experts Say. Chronicle of Higher Education, June 11, 1986: p. 27.

[81] Ibid., p. 28.

[82] The Impact of SDI Research On Universities. Presented by Linda S. Wilson, at the AAAS Symposium on Increased Spending for Defense R&D: Its Effects on University-Based Research, May 30, 1986, Phila. Penn. p. 8.

[83] Ibid., p. 9.

Not surprisingly, SDIO officials have suggested that professors in charge of SDI research, and some assisting graduate students, may be required to obtain security clearances. Such a clearance would facilitate access to relevant sources of information, including classified studies from industry and Government laboratories.[84] This requirement could prevent foreign graduate students, who now make up almost 50 percent and 40 percent of all Ph.D. engineering and mathematics students respectively, from participation in important research projects. Most university faculty believe that, once they accept a graduate student into a certain program, he or she should be allowed to pursue any area of research. Ultimately, universities may have to choose between accepting classified research or foregoing substantial research funds.

Dr. Wilson argues that many of these concerns represent potential trouble spots and may undermine many traditional university values. Such values include:

> Excellence as the dominant criterion for choice of what research to undertake and to support;
>
> Freedom of the faculty to choose what and how they teach and do research;
>
> Openness of results of university research;
>
> Independence of the institution from politically-based direction and intervention;
>
> Coupling of graduate education and research; and
>
> Integrity of scholarship and research.[85]

This line of reasoning underscores the possibility that universities may need to make choices with respect to pursuing and securing SDI research contracts. Past attempts by DOD to control the communication of research findings have reportedly had a negative effect on some university scientific meetings. For example, in expectation of Pentagon reaction, some scientific groups have:

> Withdrawn scientific papers from meetings;
>
> Limited attendance of certain foreign graduate students and visiting professors at scientific meetings;
>
> Closed certain meeting sessions to non-U.S. citizens;
>
> Allowed only very general discussions regarding research breakthroughs in SDI related technologies; [86] and
>
> Refused to attend meetings all together.

In September of 1985, twelve scientific and engineering societies, with over two million members, informed the Pentagon that their organizations would no longer sponsor restricted sessions at their meetings. In a letter to DOD, leaders of the societies indicated that if DOD wanted certain subjects restricted, it should take them out of open meetings or set up classified meetings. In their letter, the scientists and engineers stated that, "Responsibility for implementing controls for such information must lie with the Government and not with our organizations." [87] DOD responded by noting that technical data is different from basic scientific research results. Technical data involves taking scientific and engineering data and converting them into data that can be used for producing operating products and systems, while the results of basic research are relatively open-ended.

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[84] Should University Researchers Accept SDI Funding? Technology Review, Jan. 1986: p. 11.

[85] Wilson, p. 10.

[86] Because of SDI-related work, researchers can only discuss recent laser advances in general terms. Research and Development, Apr. 1986. p. 56.

[87] White House Issues Secrecy Guidelines. Science, v. 230, Oct. 11, 1986: p. 152.

In responses to these concerns, representatives from SDI have pointed out that no university-based research, supported by the ISTO, has been classified. Further, in a study of three separate university research centers (cryptology, very large integrated circuits, and systems software), many Center researchers felt there was less secrecy now than ten years ago because of better relations with their sponsors.[88] Since they are from university centers the researchers may or may not be academic in that they hold a university rank. Many Center researchers do not. Researchers in all three centers, however, agreed that further tightening of Government controls (e.g., prepublication review and greater restrictions on foreign graduate students) could lead to greater difficulties in conducting research and hamper scientific progress.[89]

## H. The Spill-Over Effect

Some in the academic community believe that recent Administration and DOD attempts to crack down on the leakage of Government-sponsored high technology research would spill over into research projects not directly funded by DOD. These concerns were confirmed in early 1985 when the Pentagon announced that it planned to prevent Soviet-bloc scientists and scientists from China access to (Government-funded) U.S. supercomputer centers.

The Department of Defense is concerned about access to supercomputer centers currently being established, with the support of the National Science Foundation (NSF), at the Unniversity of Illinois, Cornell University, University of California, San Diego, Princeton University, and, most recently, Carnegie-Mellon University. United States officials believe that the Soviet Union does not currently possess any supercomputers. There are some 170 supercomputer centers around the world (the majority in the United States), costing $10 to $30 million each. They can perform various computations at speeds of up to 400 million calculations per second.[90]

Because of their great speed, supercomputers can be used to help solve a number of very complicated military and civilian problems. For example, supercomputers can be used to develop and break sophisticated military codes, as well as design advance, particularly nuclear weapons. Dr. Stephen Bryen, Former Deputy Assistant Secretary of Defense, believes that "the lack of supercomputing is a major problem for the Soviets. It's one of the key reasons they are not moving ahead in areas such as SDI." [91] In fact, there is general consensus that access to supercomputers should be controlled. The questions are how much, how, and by whom?

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[88] Cherniavsky, John C. Case Study: Openness and Secrecy in Computer Research. Science, Technology and Human Values, Spring 1985: p. 100.

[89] Ibid., p. 101.

[90] Novus, Boeing Computer Services. Seattle, Wash., 1986. p. 10

[91] Officials Agree to Restrict Access to Supercomputers. Research and Development, Apr. 1986: p. 46.

The Pentagon wants the universities to sign NSF contracts containing a clause which would ban Soviet-bloc students from having access to any university supercomputer centers. As part of the Administration's attempt to continue good relations with the PRC, the Administration has dropped its ban on students from China.

The universities object to this clause because, they assert, it would infringe on their academic freedom. Further, university officials have indicated that these supercomputer centers are funded by NSF and will not be doing any classified research. Like many other universities, Cornell University has a policy of allowing any student or faculty member access to all campus research facilities. According to Thomas R. Rogers, the director of Cornell sponsored programs, "closed doors and restrictions on publication conflict with the university's purpose of disseminating information." [92]

Some university officials agree that the Soviet Union is actively seeking access to American technology. They recognize the Soviets have benefited greatly from the U.S. university tradition of openly discussing and publishing the results of basic research. However, many academics disagree with the Pentagon contention that the Soviets would risk using U.S. supercomputers to solve critical military problems. University officials "doubt that Soviet scientists would risk tipping their hands on key military projects by using supercomputers in the United States." [93] Michael Levine, physics professor at Carnegie Mellon, also stated that "the idea that any university is somehow going to allow unrestricted access by unknown persons for unknown activities is laughable." [94]

Administration officials believe the Government has the right to "restrict access to supercomputer facilities, on the ground that computer technology constitutes export-control technology to which foreign-national access, even within the U.S., should be restricted as a part of export restrictions." [95] DOD is concerned that foreign students may gain insights about how to build supercomputers by running programs on them. Experts argue that learning how to build a supercomputer by using one is roughly equivalent to understanding how a television works by watching "Dallas." [96] DOD fears that some members of the academic community may not understand its concerns that Soviet researchers who gain access to supercomputers might through various programming activities gain a greater understanding of the mechanics of supercomputers.

Assistant Secretary Bryen has stated that Soviet-bloc scholars are put under pressure by their Government to engage in military-related research and take advantage of access to high technology equipment not available in the Soviet Union.[97] Directors of university supercomputer centers respond that it is difficult to get time on their computers. The NSF has established a procedure in which each applicant requesting time on a supercomputer must pass through a scientific peer review process involving ten experts. According to NSF, Eastern bloc researchers receive special scrutiny, with any request for very large amounts of time receiving further analysis.

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[92] Ibid., p. 59.

[93] Curb on Campus Computers: Pentagon vs. Academia. New York Times, Aug. 17, 1895: p. 17.

[94] Ibid., p. 17.

[95] How Security Noose Is Tightening on R&D Data Flow. Science and Government Report, May 1, 1986: p. 4.

[96] Knight, Jonathan and Robert L. Park. Who Will Control the Supercomputers? The Washington Post, Aug. 17, 1985. p. 26.

[97] Officials Agree to Restrict Access to Supercomputers. Research and Development, Apr. 1986: p. 46.

Congressman Terry L. Bruce believes that the Pentagon plan to restrict access at universities will not solve the problem. He stated that the most vulnerable supercomputers are those in the private sector. For example, recent Boeing Computer Services advertisements invite researchers to purchase Boeing supercomputer time through the international teleprocessing network. Congressman Bruce asked, "Why would the Russians bother to go through the complicated peer review process at a university when it's possible simply to pick up a phone and dial a supercomputer from their lab in the Eastern bloc?" [98] Representatives from Boeing have stated that they have stringent security procedures designed to prevent any unauthorized individuals from gaining access to their supercomputers. Boeing representatives have indicated that all potential supercomputer users are subject to an elaborate screening process. Further, once the screening process is completed, Boeing requires new customers to work with an account representative before they are allowed to purchase time on the supercomputer. All customer access to Boeing supercomputers must be coordinated and scheduled through a Boeing account representative.[99]

Nearly everyone agrees that access to supercomputers should be controlled. However, negotiations between NSF and the State Department have reached an impasse. University officials want an "exemption mechanism" in proposed visa restrictions to Soviet-bloc scientists. These exemptions would allow Soviet-bloc undergraduate students to use supercomputers as part of their routine classwork. The exemptions would not allow Soviet-bloc doctoral students working independently to have access to supercomputers.

The Department of Defense does not want any exemptions for Soviet-bloc students. The Pentagon believes that Soviet-selected students' exposure to supercomputers, particularly in the university context, poses a national security risk. However, Donald Hicks, former Under Secretary of Defense for Research and Engineering, suggested that DOD needed to get better data on just what the risks are.[100] Mr. Hicks has indicated that he would like to reach agreement with the universities since "the university community is important to DOD." [101] Administration officials expect the National Security Council to decide whether or not Soviet-bloc students will have access to supercomputers.

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[98] Bruce, Terry L. Protecting Our Supercomputers. Congressional Record, extension of remarks, May 22, 1986. p. E1811.

[99] Information obtained through discussions with Boeing representatives. June 12, 1986.

[100] Turner, Judith Axler. Aide Urges Pentagon to Explain Why It Would Bar Soviets From Computers. Chronicle of Higher Education, May 14, 1986: p. 1.

[101] Ibid., p. 34.

## I. SECRECY AND COMMERCIAL SPINOFFS

Many DOD officials are now arguing that DOD support of research will produce a technological boost to the United States economy. Lieutenant General James Abrahamson, director of SDI, has stated that the SDI program "will so stimulate the national economy that it will pay for itself." [102] In a Business Week article, Dr. James Ionson, director of the ISTO has indicated "Star Wars will create an industrial revolution." He pointed out that "gamma-ray lasers designed to cripple missiles could also provide the first three-dimensional images of the nuclei of atoms. You could actually examine cells, genes, strands of DNA. The possible medical uses are absolutely spectacular." [103]

A Stanford, Connecticut, market research firm, Business Communications Company, has estimated that "the commercialization of Star Wars technology will eventually yield private-sector sales ranging between $5 trillion and $20 trillion." [104] SDI-supported research could lead to new materials development for computer optical switching that can handle up to 1 trillion operations per second, a thousand times more than current silicon switches. Supercomputer research could be used to help improve weather forecasting and developing better models for estimating the effects of human activities on the climate.[105]

Researchers at Lawrence Livermore Laboratory have developed a process utilizing a free-electron laser (a candidate for destroying ballistic missiles) that could be used for the irradiation of food. Irradiation could replace the need for chemical fumigation of crops, thus eliminating the chance that poisonous fumigants, such as ethyl bromide remain on the produce.[106]

Despite these DOD claims, critics contend that potential commercial spinoffs from DOD-supported research could remain tied up in secrecy for years.[107] For example, the Department of Defense Authorization Act of 1984 gives the Secretary of Defense the authority to "withhold from public disclosure . . . any technical data with military or space application in the possession of, or under the control of, the Department of Defense, if such data may not be exported lawfully without an approval, authorization, or license under the Export Administration Act . . . or the Arms Export Control Act." [108] Further, a recent DOD directive restricted the availability of sensitive technical data with potential military application to "currently qualified U.S. contractors," who require the technical data to "bid or perform on a contract with the Department of Defense. . . ." [109] Thus, entrepreneurs, anxious to convert the fruits of

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[102] Gutrel, Fred V. Star Wars Is Bad for Business. Dun's Business Month, Sept. 1986: p. 56.

[103] Why Star Wars is a Shot in the Arm for Corporate R&D. Business Week, Apr. 8, 1985: p. 78.

[104] Browne, Malcolm W. The Star Wars Spinoff. New York Times Magazine. Aug. 24, 1986: p. 25.

[105] Ibid., p. 26.

[106] Browne, Malcome W. Star Wars Science Expected to Spawn Peaceful Inventions. New York Times, Apr. 2, 1985: p. c9.

[107] Guterl, p. 56.

[108] Department of Defense Authorization Act, 1984, P.L. 98-94, Sept. 24, 1983, (Stat 614, 690-691). Section 1217 (10 USC 140c).

[109] U.S. Dept. of Defense, Directive, no. 5230.25, Nov. 6, 1984. p. 4.

SDI research for commercial purposes, may not have access to the technical data required.

Since the beginning of the Reagan administration, the Pentagon has increased from 13 to 20 percent that portion of their R&D budget they will not discuss for national security reasons. Executive Order 12356 makes it easier to classify research documents.[110] A higher percentage of SDI research conducted by defense contractors is classified in part. Scientists doubt that "SDI research will be communicated freely in light of the Reagan Administration's touchiness about the dissemination of unclassified research with military potential." [111]

However, General Abrahamson minimizes the long-term concerns of the transfer of technology to the private sector because of secrecy. General Abrahamson has said "I am determined that we not miss the opportunity to capitalize on the results of SDI research and apply it across all facets of our economy and society." [112]

Nevertheless, based on current and future research areas DOD is likely to support, past attempts by the Administration to restrict the dissemination of scientific and technological information, and the natural tendency of academic researchers to dislike restrictions, many scientists and university administrators believe that limitations on access to scientific information will continue to be a problem.

## J. Conclusion

Many within the university research environment feel that the primary purpose of campus-based research is the advancement of knowledge, which occurs most effectively in an atmosphere of "academic freedom" with minimal Government controls on the sharing of research findings. While the Pentagon recognizes the importance of freedom of inquiry in scientific research, the DOD also believes that it has an equally important responsibility for preventing some types of scientific and technological information from being transmitted illegally to the Soviet Union and its allies. Recent developments have highlighted an extensive Soviet organization devoted to the acquisition of new Western science and technology by any and all means, including espionage in selected targeted universities. See chapter IV.

The future of national security controls of university research is likely to remain a difficult policy arena. Even with relatively high levels of cooperation between the academic and national security communities, there are multiple tensions inherent in resolving policies involving fundamental issues such as: freedom of speech, academic freedom, health of the Nation's scientific establishment, potential technological spinoffs, and national security concerns.

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[110] Reich, Robert B. High Tech, a Subsidiary of Pentagon Inc. The New York Times, May 29, 1985: p. A23.

[111] Guterl, p. 57.

[112] Browne, Malcolm W. The Star Wars Spinoff. New York Times Magazine, Aug. 24, 1986: p. 26.

## CHAPTER XI

# THE SCIENTIFIC ADVISORY SYSTEM OF THE DEPARTMENT OF DEFENSE*

### A. INTRODUCTION

(Note: This chapter was drafted before termination of the Office of the Under Secretary for Research and Engineering in 1986.)

Almost all Federal agencies which support research and development seek advice on programmatic and policy issues from scientists and technologists working in universities, industry and other private institutions. These individuals serve as consultants as well as members of scientific advisory committees. They represent the military component of "an influential scientific advisory committee system," which has been called "perhaps one of the most important innovations in public administration in this century. . . ." which ". . . permits DOD (and other Federal agencies) to maintain a continuous dialogue with the scientific community."[1]

The Department of Defense has an elaborate scientific and technical advisory mechanism, with ad hoc and permanent scientific advisory committees at many levels, to advise individual laboratories, military service chiefs, and the Office of the Secretary of Defense. At the laboratory level scientists advise on technical matters. For instance an aeronautical laboratory might establish a committee "to tackle design problems of a specific airfoil." [2] At the level of the Office of the Secretary of Defense, the Defense Science Board, the principal advisory body, has dealt with both specific and broad policy including such issues as scientific manpower, defense industrial preparedness, the quality of the "technology base," technology transfer policy, and standardization of weapons systems in NATO. Each branch of military service also has a scientific advisory mechanism comparable to the Defense Science Board: the Army Science Board (formerly called the Army Scientific Advisory Panel), the Naval Research Advisory Committee, and the Air Force Scientific Advisory Board. The now-terminated President's Scientific Advisory Committee (PSAC) which advised the President, and the current White House Council on Science and Technology, which advises the Director of the Office of Science and Technology Policy, also have played crucial advisory roles on defense research and development issues.

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*Prepared by Genevieve J. Knezo, Specialist, Science and Technology, Science Policy Research Division.

[1] Sanders, Ralph, ed. Defense Research and Developoment. Washington, Industrial College of the Armed Forces, 1968, p. 37.

[2] Landis, Lincoln and Kendall W. Simmons. Science, Technology, Research and Development. Industrial College of the Armed Forces, 1974. Washington, p. 92-93.

The major policy issues of concern regarding the advisory bodies are the need to balance the potential for conflict of interest against the need for specific kinds of advice that only experts can provide, the utility of scientific and technical advisory bodies, and the role of the Office of Science and Technology Policy and its predecessor, the Office of Science and Technology, and their affiliated advisory groups in determining policy and programs for military R&D. These issues are discussed below, but they are preceded by descriptions of the origins and composition of military advisory bodies.

## B. The Defense Science Board

The Defense Science Board (DSB) was established in 1956 to provide objective scientific and technical advice to the Office of the Secretary of Defense. The Board's reports and recommendations are made directly in response to requests of the Secretary of Defense, the Under Secretary of Defense for Research and Engineering, or the Chairman of the Joint Chiefs of Staff.

### 1. CREATION AND EVOLUTION OF MEMBERSHIP STRUCTURE [3]

The DSB was created in 1956 as a response to a recommendation made by the Hoover Commission on Organization of the Executive Branch of the Government that:

> The Assistant Secretary of Defense (Research and Development) will appoint a standing committee, reporting directly to him, of outstanding basic and applied scientists. This committee will canvass periodically the needs and opportunities presented by new scientific knowledge for radically new weapons systems.[4]

Originally the board had 25 members, consisting of the chairmen of the 11 technical advisory panels in the Office of the Assistant Secretary of Defense (Research and Development), the Chairmen of the senior advisory committees of the three services; the directors of the National Science Foundation, the National Bureau of Standards, and the National Advisory Committee for Aeronautics (the predecessor of the National Aeronautics and Space Administration); the President of the National Academy of Sciences; and seven members-at-large drawn from the scientific and technical community.

A charter that specified that the board would be an advisor to the Assistant Secretary of Defense (for Research and Development) was issued on December 31, 1956. In 1957, the offices of the Assistant Secretaries of Defense (Research and Development) and (Applications Engineering) were consolidated, and thereafter the board was reconstituted as an advisor to the Secretary of Defense through the new office of the Assistant Secretary of Defense (Research and Engineering). Its membership was increased to 28. Among its ex officio members were the chairmen of President's Scientific Advisory Committee and of the Scientific Advisory Committee in the Office of Guided Missiles. A revised charter was issued on October 30, 1957.

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[3] Taken largely from: U.S. Dept. of Defense. Office of the Under Secretary of Defense for Research and Engineering. Defense Science Board. Background, Biographical Sketches and Activities. Washington, 1985, passim.

[4] Ibid., p. 1.

As a result of Department of Defense Reorganization Act of 1958, which outlined the functions of the new office of the Director of Defense Research and Engineering (DDR&E), the board's charter was revised on November 23, 1959. The DSB role was redefined in conformity with the DDR&E's responsibilities. In addition the new charter prescribed eight members-at-large and modified ex officio membership "to conform with the establishment or dissolution of advisory panels in the office of the DDR&E." [5] A revised board charter was issued on April 10, 1961, to reflect the formal designation of assistant directors for different types of warfare in the office of DDR&E in 1959. A directive revising the charter was reissued on February 17, 1971. In 1978 the office designation, Director of Defense Research and Engineering, was changed to Under Secretary of Defense for Research and Engineering (USDRE), and the directive defining the board's charter was revised to reflect the change.

Today the board has 33 members, including as ex officio members, the chairmen of the three principal scientific advisory bodies of the services. There are 30 members-at-large, appointed for four-year terms, who are—

> selected on the basis of their pre-eminence in the fields of science and engineering, including management and long-range planning, to represent the interests of the Under Secretary of Defense for Research and Engineering, the Secretary of Defense, and the Chairman of the Joint Chiefs of Staff.

The board is assisted by nine senior consultants, who are pre-eminent scientists and engineers and who advise on specific tasks. The Secretary of Defense appoints members "based in part on recommendations provided to him by the DSB chairman and the Under Secretary of Defense for Research and Engineering, in turn based on nominations received from a broad spectrum of individuals.[6]

Board membership appears to favor physical scientists and engineers and officers of industrial firms which do defense RDT&E work, as opposed to university professors. Of the Board members and consultants in 1985, 34, or 81 percent, were physical scientists and engineers, and 25, or 58 percent, were officers of industrial firms.[7] Retired military officers, university presidents, and Nobel laureates have been members of the DSB.

### 2. FUNCTIONS

The Board's role is strictly advisory and it has no decision-making authority. All of its work is initiated upon formal approval of a written task statement by the Under Secretary of Defense for Research and Engineering. The DSB conducts it activities via ad hoc task forces, which are composed of at least two DSB members, and also senior consultants and outside experts selected by the Task Force chairman with the approval of the DOD. An effort is made to secure independent advice. Task Forces may issue reports and recommendations. DOD reports that an attempt is made to secure balance in representation of views of task force members and that "individuals with preconceived options on matters at hand are in fact generally avoided." [8] The DSB usually undertakes in-depth program and policy reviews during its "summer studies" meetings.

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[5] Ibid., p. 2.

[6] Statement of Paul Thayer. Deputy Secretary of Defense. In U.S. Congress. House. Committee on Government Operations. Favoritism and Bias Within the Defense Science Board and Other Military Advisory Panels. Hearing before a Subcommittee. 98th Congress, 1st sess. Sept. 22, 1983. Washington, U.S. Govt. Print. Off., 1984, p. 85.

[7] Defense Science Board, 1985, op. cit., p. 3.

Many, if not most, board members serve without compensation. Those that are paid receive about $200 per day, generally considered to be substantially less than the standard industrial consulting rate. It was estimated in 1983 that travel and per diem costs totaled about $200,000 annually and that the activities of the DSB cost about $1 million per year.[9]

## C. INVENTORY OF DEFENSE SCIENCE BOARD ACTIVITIES

Many Federal agencies which support research have advisory bodies to communicate with non-governmental scientific and technical experts, to solicit their opinion about priorities for support, or about organizational and policy issues. These groups are often praised because, if they are constituted independently and function effectively, they can provide Federal decisionmakers, often without reimbursement, with access to the most up-to-date information and thinking available. These activities can help trim costs and expedite the application of science and technology and the development of broad policy in the national interest. In the case of the DSB, because members often are experienced policymakers or policy analysts, the DSB has also advised on broad defense and strategic policy.

Over the years, the DSB, according to a recent House Government Operations Committee report, has provided advice and recommendations affecting the use of "billions of taxpayer dollars." [10] It has issued over 200 reports and papers. "In some cases," according to DOD, "Congress has requested the Board to review a particular issue because of its reputation for expertise, objectivity and independence." [11] For instance in the FY1986 defense authorization bill, the Congress directed that the Defense Science Board undertake an "independent review of the Midgetman Small ICBM . . . and to submit the results to the Congress" [12] prior to the submission of the FY1987 defense budget to aid in funding deliberations. Many of the topics of DSB advice center on the technological development end of the spectrum of RDT&E activities. Nevertheless, in the areas of science and research the DSB has issued reports which recommend policies in such crucial areas of DOD and national R&D funding policy as: long-range science and technology investment strategies,[13] chemical and biological warfare, development of policies for international technology transfer which are balanced between serving needs of national security and international commerce, scientific and technical personnel training, management of R&D, and maximizing returns on research investments in universities while enhancing the university infrastructure.

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[8] U.S. Congress. House. Committee on Government Operations. Favoritism and Bias Within the Defense Science Board and Other Military Advisory Panels. Hearings before a Subcommittee. 98th Congress, 1st sess., Sept. 22, 1983. Washington, U.S. Govt. Print. Off., 1984, p. 86.

[9] Robinson, Clarence A. Jr. Audit Clouds Science Board Future. Aviation Week and Space Technology, v. 119, Sept. 5, 1983: 20.

[10] U.S. Congress. House. Committee on Government Operations. Defense Science Boards: A Question of Integrity. Twenty-seventh report . . . together with additional views. 98th Congress, 1st sess. Union Calendar no. 328. Washington, U.S. Govt. Print. Off., 1983 p. 4.

[11] Favoritism and Bias Within the Defense Science Board and Other Military Advisory Panels, op. cit., p. 86.

[12] Defense Science Board to Study Midgetman For Congress. Defense Daily, v. 141, Aug. 15, 1985: 1.

The following is a list of DSB reports issued during the period 1958 to 1985 that deal with aspects of science and technology base work.[14]

*1959*

Report of the Task Group on Biological and Chemical Weapons Development, DSB, 18 February 1959, Volumes I and II (Secret).

*1960*

The Technology of Human Behavior, July 1960, For official use only (done under the cognizance of DSB, but not directly by DSB).

Report of the Task Group on Structure of Scientific and Engineering Advice, DSB, 29, September 1960, Unclassified.

*1962*

Report of the Defense Science Board on Government In-House Laboratories, 6 September 1962, unclassified.

*1963*

DSB Subcommittee Final Report on Scientific and Technical Information, 16 July 1963, Unclassified.

Report of DSB Subcommittee on Department of Defense Research Policy, Part I, "Policy in Support of Basic Research," 31 December 1963, Unclassified.

*1964*

Report of the DSB Subcommittee on Encouragement of Innovation, 17 September 1964, For Official use Only (Report and Supplement).

*1965*

Report of DSB Subcommittee on Department of Defense Research Policy, Part II, "Further Analysis of Basic Research Policy," 14 January 1965, Unclassified.

Research in the Department of Defense on Internal Conflict and Insurgency in the Developing Countries: Final Report of DSB Subcommittee on Behavioral Sciences, 30 January 1965, For Official Use Only.

Report of DSB Subcommittee on Technical Military Personnel, 9 September 1965, Unclassified.

Report of DSB Subcommittee on Management of Research and Exploratory Development, 9 September 1965, Unclassified.

*1966*

Report of DSB Subcommittee on Civilian Technical Personnel in the Department of Defense, 9 February 1966, Unclassified.

Federal Contract Research Centers, 27 October 1966, For Official Use Only, (Memorandum Report).

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[13] Edith W. Martin, former Under Secretary for Defense Research and Engineering reported that in 1981, the DSB identified 17 technologies which, if given more funding attention, "could make a difference" and which have multiple military applications. They included: very high-speed integrated circuits, advanced software algorithm development, micro-processor-based personal learning aids, rapid solidification technology, machine intelligence, supercomputers, advanced composites, high density monolithic focal play arrays, radiation-hardened advanced electronics, space nuclear power, and short wavelength lasers. (In Edith W. Martin. DOD Research: Today's Challenges and Implications for Tomorrow. Grants Magazine, v. 6, Sept. 1983: 154.)

[14] These items were taken from Reports of the Defense Science Board. [1958 to 1984]. This original list identifies 212 reports that DSB prepared between 1958 and 1984, many dealing with other defense related subjects.

Report of DSB Task Force on In-House Laboratories, 31 October 1966, Unclassified.

Report of DSB Task Group on Incentive-Type Contracting in the Procurement of RDT&E, 1 November 1966, Unclassified.

*1967*

Report of DSB Task Group on Independent Research and Development, Unclassified with Supplement 1, 1 February 1967, For Official Use Only.

Research and Exploratory Development, Unclassified, Report from the DSB-NAS Summer Study, 5-14, July 1967.

Defense Social and Behavioral Sciences Unclassified, Report from the DSB-NAS Summer Study, 5-14, July 1967.

Fees for Federal Contract Research Centers, 20 December 1967, For Official Use Only (Supplementary memorandum Report).

*1968*

Report of DSB Task Force on Basic Research Policy of the Department of Defense, 20 February 1968, Unclassified.

Report of DSB Task Group on The Behavioral Sciences, 8 May 1968, Unclassified.

Research Policy, Unclassified, Report of DSB-NAS Summer Study, 23 June-5 July 1968.

Behavioral Sciences: "Research and Development Programs Required to Achieve Training of Military Advisory Groups," Confidential. "Relationships between Foreign Area R and D Programs Sponsored by the DOD and Those of Other Government Agencies," Unclassified.

*1969*

R and D Management, Unclassified. Report of DSB-NAS Summer Study, 7-18 July 1969.

*1970*

Report of the DSB Task Force on Secrecy, 1 July 1970, Unclassified.

*1971*

"Manpower Research and Management in Large Organizations," Final Report of DSB Task Force on Manpower, June 1971, Unclassified.

*1973*

Report of the Task Force on Reducing Costs of Defense Systems Acquisition, Design to Cost, Commercial Practice vs. Department of Defense Practice, 15 March 1973, Unclassified.

Report of the DSB Net Assessment Task Force Study of Unidentified R and D Activities, May 1973, Special Access.

*1975*

An Analysis of Independent Research and Development/Bid and Proposal (R and D/B and P): A Report of the DSB IR and D Task Force, March 1975, Unclassified.

*1976*

An Analysis of Export Control of U.S. Technology—A DoD Perspective: A Report of the DSB Task Force on Export of U.S. Technology, 4 February 1976, Unclassified.

Summary Report of the DSB Task Force on Training Technology, 27 February 1976, Unclassified.

Report of DSB Task Force on Federal Contract Research Center Utilization, February 1976, Unclassified.

Report of DSB Task Force on Technology Base Strategy, October 1976, Unclassified, Report of the DSB Summer Study, 3-15 August 1975.

Report of DSB Summer Study Group on Fundamental Research in Universities, October 1976, Unclassified.

Report of DSB Task Force on Industrial Readiness Plans and Programs, 15 November 1976, Secret.

*1981*

Report of the DSB 1981 Summer Study Panel on Technology Base, November 1981, Secret and Unclassified versions.

*1982*

Report of the DSB Task Force on University Responsiveness to National Security Requirements, January 1982, Unclassified.

DSB Task Force on the Review of the Defense Nuclear Agency Technology Base Program, March 1982, Unclassified.

1982 DSB Summer Study Briefing Report for Training and Training Technology, 26 July–6 August 1982, Unclassified.

Report of the DSB 1982 Summer Study Panel on Training and Training Technology, November 1982, Unclassified.

*1984*

Report of the Defense Science Board Task Force on Military Applications of New-Generation Computing Technologies, December 1984, Unclassified.

*1985*

Report of the Defense Science Board Task Force on "Journal of Defense Research (JDR)," June 1985, Unclassified.

### D. THE SERVICES' ADVISORY COMMITTEES

Each service also has an advisory committee which performs functions similar to those of the DSB for their respective Army, Navy, or Air Force Secretaries and service chiefs. The bodies are structured like the DSB; a chairman and vice chairman is selected by the service secretaries, the committees have executive directors, and they conduct their work via constituent panels or task forces, which may be augmented by outside experts.

The Naval Research Advisory Committee (NRAC) was formed in 1946, pursuant to P.L. 79–588. Its function is to advise the Secretary of the Navy, the Chief of Naval Operations, and the Chief of Naval Research about issues of research and development. By statute the committee is composed of 15 civilian members preeminent in the fields of science, research, and development, with one member representing medicine. The members must be approved by the Secretary of Defense; members' terms are staggered and rotated every two years. Like the DSB, the NRAC operates via task forces.

The Air Force Scientific Advisory Board (SAB) was created in 1947 and reports directly to the Secretary of the Air Force.[15] It is comprised of 67 civilian members, and operates, like the other advisory boards, via panels. There are five standing panels: aeromedical-biosciences, aeronautics, electronics, sciences, and weapons. Members are appointed by Secretary of the Air Force for three-year terms. They are assisted by the military director, who is a deputy chief of staff for research, development, and acquisition. A recent DOD description reported—

> in its advisory capacity, the Board reviews USAF long-range plans for R&D, makes studies to improve the USAF R&D programs and recommends unusually promising scientific developments for selective USAF emphasis and new scientific discoveries or techniques for practical application to weapons or support systems.[16]

The Army Scientific Advisory Board (ASB) was created in 1977 and combines the functions of at least five predecessor groups, the Army Scientific Advisory Panel; Ballistic Missile Defense Technology Advisory Panel; Ballistic Research Scientific Advisory Committee; Tank Automotive Research and Development Command Scientific Advisory Group; and Scientific Advisory Group of the U.S. Army Missile Command. The Board is composed of a maximum of 100 civilian members who provide advice to Army leadership on issues relating to science, technology, engineering, and testing acquisition. In order to eliminate favoritism "there is a policy that limits participation on the ASB (or any Ad Hoc Subgroup of the ASB) to two members from any one corporation, university, or consulting firm at any point in time." [17] The Board operates via study panels, which may also include military personnel.

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[15] For additional historical information see: Sturm, Thomas A. The USAF Scientific Advisory Board. Its First Twenty Years, 1944–1964. Washington, U.S. Govt. Print. Off., Feb. 1, 1967, 194 p.

[16] Favoritism and Bias Within the Defense Science Board and Other Military Advisory Panels, op. cit., p. 104.

## E. CRITICISMS OF THE POTENTIAL BIAS OF THE DEFENSE SCIENCE BOARD AND OTHER ADVISORY BODIES

On balance, DSB advice is regarded as being technically sound and useful to the extent that Congress sometimes mandates, via authorization or appropriations language, that the DSB perform certain studies.[18] However, over the years the DSB and the other advisory committees have been criticized for having the potential for bias and for making unrealistic recommendations. For instance in 1968, a text published by the Industrial College of the Armed Forces, which is part of the National Defense University, noted the potential for distortions in the objectivity of DSB advice:

> For the most part, DOD selects scientific advisers in an informal way, relying upon the recommendations of scientists already advising DOD. Since personal acquaintance weighs heavily, scientists may recommend those colleagues who agree with their ideas; unless care is exercised this can result in self-perpetuating scientific committess.[19]

Norman R. Augustine, who is a member of the Defense Science Board testified in October 1985 before the Task Force on Science Policy that his:

> experience has been that it is becoming almost untenable to assemble a group which is competent and experienced in a given area, yet which has no connections in that same area which could lead even to a perceived conflict of interest. On the other hand, the integrity of the advice being given to the government must be absolutely without reproach. Unfortunately, I do not have a solution to this problem.

Yet, he said, it was very rare to have seen an advisor operating with other than the best interests of the government in mind.[20] However, he recommended that: ". . . [A] much clearer delineation of whatever is to be the government's policy in this regard is badly needed out of fairness to both the advisor and the advised.[21]

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[17] Favoritism and Bias Within the Defense Science Board and Other Military Advisory Panels, op. cit., p. 69.

[18] Robinson, Clarence A., Jr. Audit Clouds Science Board Future. Aviation Week and Space Technology, v. 119, Sept. 5, 1983: 16. As a example cited was a study on space-based lasers requested by the Senate Armed Services Committee (Robinson, op. cit., p. 19.)

[19] Sanders, Defense Research and Development, op. cit., p. 38.

[20] Statement of Norman R. Augustine, Committee on Science and Technology, Oct. 23, 1985: p. 5.

During the 98th Congress, the House Government Operations Committee, the DOD Inspector General's Office, and the General Accounting Office assessed the objectivity and independence of the Defense Science Board, partially in response to the request of the board chairman, Norman R. Augustine.[22] Subsequently the Committee issued a report which concluded that the DSB and the other scientific advisory panels were, in several instances, biased and favored particular industrial interests because of their selection and operations the bodies ". . . virtually ignored the requirements and ethical standards embodied in [the Federal Advisory Committee Act and the conflict of interest statutes.]" [23] The violations included not obtaining required statements of financial interests, using selection procedures which did not allow for effective conflict-of-interest reviews or for obtaining a balance of views on panels, selecting task force members of the advisory boards "from personal acquaintances and an old-boy network within the militiary-industrial complex" and allowing undue influence by miltitary personnel from offices which potentially would be affected by the panel's decisionmaking and recommendations.

The 1983 Inspector General's report observed that required public minutes were available for only about one-sixth of the task force board meetings held between 1977 and 1982. Reportedly ". . . the minutes that were kept shed little light on what was discussed, what was decided or even who was present. . . ." [24] It also found that 106 of 124 of the financial disclosure statements that were filed from DSB task forces ". . . showed a significant financial interest in an organization doing business with the Department of Defense which is interest defined [by law] as a potential conflict of interest." [25] In addition 189 financial disclosure statements should have been filed. Many of the task forces studied involved advice of a nature which could have been advantageous for the employers of task force members.[26] In addition it was charged that the board kept only few minutes of its meetings and that many of the mintues kept were so sparse as to convey little useful information.[27]

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[21] Augustine, op. cit., p. 6.

[22] Idem.

[23] U.S. Congress. House. Committee on Government Operations. Defense Science Boards: A Question of Integrity. 98th Congress, 1st sess. House Report no. 98-580. Nov. 28, 1983. Washington, U.S. Govt. Print. Off., 1983, p. 2. See also: U.S. Comptroller General. Objectivity of DOD's Senior Scientific Advisory Committees Can Be Better Assured. Report to the Chairman, Committee on Government Operations, House of Representatives, Sept. 21, 1983, GAO/GGD-83-76.

[24] Yoder, Eric, Defense Board Reeks of Conflicts. Federal Times, v. 19, Sept. 5, 1983: 1.

[25] Ibid., p. 5.

[26] Idem. The following organizations and firms had the most members sitting on the most Defense Science Board task forces between January 1978 and August 1982:

University of California, 15.
R&D Associates, 9.
The MITRE Corp., 8.
Bell Laboratories, 8.
TRW, 8.
Hughes Aircraft, 7.
E.G. Fubini Consultants, 7.
Texas Instruments, 7.
The Aerospace Corp., 6.
Raytheon Corp., 5.

(Ibid., p. 5.)

[27] Idem.

On the basis of the several reports and its own investigation, the Government Operating Committee concluded:

> If DOD does not move quickly to remedy deficiencies in its administration of these scientific advisory boards, they will, for all practical purposes, become an arena for the advancement of private interests under the guise of scientific advice. If this should happen, the Pentagon will be relying solely on the military-industrial complex for advice on how to spend hundreds of billions of dollars. Until DOD recognizes the real dangers created by such questionable relationships, the American taxpayer and the Congress cannot be assured that advisory board findings and recommendations serve the best interests of the country. In the meantime, the credibility of DOD's senior scientific advisory boards has been seriously damaged, perhaps irrevocably. Unless immediate action is taken to restore public confidence in these boards, it is questionable whether they should continue to exist.[28]

The committee included among its recommendations the opinion that the Secretary of Defense:

> Move the administrative and operational control of Defense Science Board activities from the Office of the Under Secretary of Defense for Research and Engineering to an independent office reporting to the Deputy Secretary of Defense. Similar actions should be taken regarding the military services' advisory boards.[29]

The DOD did not make this organizational change. However it has taken other actions to improve the DSB's objectivity including:

—appointment of an ethics counselor by the DOD general counsel;
—institution of the requirement for the completion by DSB and task force members of a confidential statement of affiliations and financial interests and the initiation of steps to ensure that task force members do not appear to have conflicts of interest;
—disqualification to work on task forces if a consultant has financial conflicts of interest;
—maintenance of a balanced composition of membership in task forces, and expression of the minority opinion when consensus is not reached in a task force report;
—publication of notices of task force meeting in the *Federal Register,* and
—appointment of a military assistant to oversee the activities of each task force.

Also, the General Accounting Office in a 1984 follow-up to its 1983 investigation entitled *Policies, Procedures, and Practices for Operation of the Defense Science Board,* examined whether the DSB had taken steps to remedy the problems identified. It concluded that the follow-up studies of the DOD Inspector General "supported his conclusions that DOD has taken or is taking action to correct the problems." [30] It observed that "Our review of financial disclosure statements revealed no apparent conflicts of interest." [31]

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[28] Defense Science Boards: A Question of Integrity, op. cit., p. 2.

[29] Defense Science Boards: A Question of Integrity, op. cit., p. 13–14.

### F. Issues About the Utility of DSB Reports

There are no definitive studies regarding the utility of DSB advice for the formulation of military research programs and policies. Such an assessment would require some analysis of the actual decisions that were made following DSB deliberations and reporting on particular issues. Such an exercise is beyond the scope of this report. Anecdotal evidence (that is, the literature regarding DOD R&D, news articles, and interviews) shows that DSB reports do influence, if not shape, significant programmatic and policy decisions in DOD and in other agencies. Particularly notable in this respect are the 1976 report on *An Analysis of Export Control of U.S. Technology—A DOD Perspective*, commonly referred to as the Bucy report, which sets forth the rationale for controlling exports of "technical processes" as opposed to technical products; and the 1981 report on the *Technology Base*, which, together with the 1982 report *University Responsiveness to National Security Requirements*, has been used in shaping recent DOD policies regarding cooperation with universities, creation of special instrumentation, teacher training, and fellowship support programs for universities.

However, questions have also been raised about the utility of the Board's work. For instance, the potential irrelevance of some recommendations was described in a report published by the National Defense University:

> [With respect to the DSB] [t]he problem of responsibility perhaps causes the major concern. Usually, scientific advisers have no responsibility for carrying out a program or for its consequences. Critics point out that without this responsibility and the knowledge it brings, advisory committees tend to make unrealistic recommendations.[32]

Yet, the authors concluded, "the Department uses these committees rather than its permanent staffs precisely because committee members are removed from the pressures of day-to-day operations and from the bureaucratic conflicts that inevitably surround R&D issues." [33]

In addition, probably in an oblique allusion to the Board, in hearings before the House Task Force on Science Policy in October 1985, DSB member Norman Augustine said:

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[30] U.S. General Accounting Office. Follow up Review of Dept. of Defense Actions to Correct Problems in the Operation of the Defense Science Board (GAO/GGD-84-49.) Report B-199008, Feb. 13, 1984, p. 1.

[31] Idem. As an illustration of improvements in complying with the law, GAO wrote that "In one case, the members of a task force were asked to determine how DOD can best capitalize on the high performance supercomputers that should result from its research programs by 1990. The terms of reference for that task force state that it is not anticipated that the task force inquiry will need to go into any particular matters. We were advised that a determination was nevertheless made to exclude an employee of a major DOD computer contractor from the task force." (Ibid., p. 4.)

[32] Landis and Simmons, op. cit., p. 93.

[33] Idem.

> . . . It has been my experience that most advisory committees tend to be reactive—mainly reviewing in being activities rather than taking the lead in suggesting new and promising avenues to be pursued. This is perhaps the major failing of the advisory board process as it exists today.[34]

## G. OTHER ADVISORY MECHANISMS

Throughout its history the Department of Defense has also received advice from a variety of other bodies—some formal and some more ad hoc. A few examples follow.

### 1. THE JASON GROUP

Academic scientists have always been an attractive and rich source of advice on military research and technological development. Beginning in the late 1940s academic scientists, especially those at the Massachusetts Institute of Technology (MIT), some of whom had taken part in the successful Manhattan Project to build an atom bomb, began a series of summer studies under Government contract for the Department of Defense. These generally were intended to find technological solutions to major military problems. Project Lexington was a 1948 MIT study sponsored by the Air Force on the feasibility of building a nuclear-powered bomber.[35] A series of MIT summer studies that became known as the "Cape Cod" series encompassed: Project East River. which focused on civil defense shelters; Project Troy, counter-measures to radio jamming; Project Beacon Hill, which looked at aerial reconnaissance and intelligence-gathering; and Project Charles, which was a study of continental air defense.[36] A 1951 study prepared by the California Institute of Technolgy, dubbed VISTA, focussed on tactical nuclear weapons and warfare.

During the height of the McNamara era in the Defense Department scientific advice was increasingly sought from outside the DOD. In 1966, some of the theoretical physicists who had participated in Project Charles, and who were dubbed the original "Charles River gang," [37] formed the nucleus of the JASON group, which recommended a technological solution to the Vietnam war—" 'an electronic battlefield'—a sophisticated array of sensors and weapons meant to confront the insurgents with a technological no-man's land in the demilitarized zone between North and South Vietnam." [38] Although this proposal was rejected, the JASON group continues to offer substantial, technical advice to the DOD. Its activities were described in a 1982 article:

> Each summer the JASON group meets weeks . . . . They advise the Department of Defense on what they term theoretical issues, such as the MX missile-basing system, and the vulnerablity of missile silos. Over the years,

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[34] Augustine, op. cit., p. 6.

[35] Herken, Gregg. Counsels of War. New York, Alfred A. Knopf, 1985, p. 60.

[36] Ibid., p. 61.

[37] Identified as Jerrold Zacharias, George Kistiakowsky, Carl Kaysen, and Isidor Rabi in Herken, op. cit., p. 211.

[38] Herken, ip. cit., op. 211.

> JASON has advised the Pentagon on such theoretical questions as the military application of lasers and particle beams. The group is administered by SRI International, . . . .[39]

### 2. CONTRACTED ADVISORY SERVICES

Studies and advice on scientific and technological issues have also been purchased through the non-profit research institutes and Federal contract research centers established by the DOD and the services, including the RAND Corporation, funded initially by the Air Force to study new strategies; the Institute for Defense Analyses; and the MITRE Corporation, which was formed in 1958 by a group of engineers from MIT who had been asked by the Air Force to conduct substantial amounts of applied research on campus. After the university refused ("stating the work was improper for a university"), the engineers formed their own firm, which is estimated to receive military contracts in excess of $135 million annually.[40] Today approximately five percent of the DOD R&D budget is performed by this kind of organization.

The DOD and the services also utilize the advice of panels convened by the National Academy of Sciences, the National Research Council, and the National Academy of Engineering to review research priorities and advise on specific issues.[41]

### 3. THE DOD-UNIVERSITY FORUM

The DOD-University Forum was created as an advisory committee in 1983 in response to a recommendation of a Defense Science Board task force to establish a forum to permit periodic consultation between DOD and university officials on research-centers issues and to "advise the Department of Defense on a wide range of issues affecting the nation's university research and education programs vital to national defense." [42] It is jointly sponsored by DOD and three higher education associations: the Association of American Universities, the National Association of State Universities and Land Grant Colleges, and the American Council on Education. University-affiliated members are nominated by the affiliated education associations, and are subject to approval by the Secretary of Defense. The forum, which advises the Under Secretary of Defense for Research and Engineering, has dealt with such topics as export control policies, engineering, science education, and foreign language and area studies.[43] The Forum was instrumental in recommending several initiatives to improve the scientific capability of U.S. universities, including the university research initiative and instrumentation programs.

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[39] Rosenau, William. The Warriors of Academe. Inquiry, v. 5, Feb. 15, 1982: 14-15.

[40] Rosenau, op. cit., p. 15.

[41] See for example, Defense Dept. and Basic Research Funding. Chemical and Engineering News, Nov. 4, 1985: 24

[42] Charter, DOD-University Forum.

[43] Report of the DOD-University Forum. Calendar Year 1984. Washington, Office of the Under Secretary of Defense for Research and Engineering, Dec. 1984.

### 4. OST AND OTHER WHITE HOUSE ADVISORY GROUPS

From time to time presidents have established commissions or groups to serve as direct advisors on specific military issues. One of the recent activities of this nature was President Reagan's commissioning of a group headed by former NASA Administrator James Fletcher to assess technical issues related to his proposal for the strategic defense initiative. The group concluded that research and technology development should be inaugurated to meet the announced objectives.[44]

Both the President's Science Advisory Committee (PSAC) and its related but not identical successor, the White House Science Council, and the offices with which they were affiliated, the Office of Science and Technology and the current Office of Science and Technology Policy, have played crucial roles with respect to advising the President on military and national security policies as well an on specific weapons systems.

There has always been a link, even if somewhat tenuous, between the presidential scientific advisory apparatus and the military. History tends to show that the most important determinant of the importance of the advice provided by the Presidential scientific apparatus is the access of the advisory group to the President. During the period of demobilization following World War II, the individuals who had formed the core of the scientific and technical advisory office for the war effort (the OSRD) shifted their attention to the civilian sector and were instrumental in laying the foundation for the creation of a National Science Foundation and in fashioning the principles and some of the apparatus of the Government-science link that has been so fruitful in the United States. Subsequently, the first post World War II White House science and technology mechanism was created because of a military necessity. On April 20, 1951, President Harry S. Truman established an 11-member Science Advisory Committee in the Office of Defense Mobilization in the Executive Office of the President ". . . to advise the President and Mobilization Director Charles E. Wilson in matters relating to scientific research and development for defense," in particular with respect to the Korean conflict.[45] Although the committee did not play a crucial role in scientific and technological decisionmaking, it continued, after the termination of hostilities, to advise the National Security Council about deterrence and survival against nuclear attack, according to David Z. Beckler, who served as executive officer of the President's Science Advisory Committee (PSAC), and assistant to the first six Presidential science advisors. The PSAC was created (from a reconstituted ODM Science Advisory Committee) in 1957, following the launch of the Soviet Sputnik, with the announced aim of "assuring that the Nation's entire science and technology program for responding to the Soviet challenge would be carried forward in a closely integrated fashion."[46]

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[44] U.S. Dept. of Defense. The Strategic Defense Initiative: Defensive Technologies Study, Apr. 1984. Washington, U.S. Gov. Print. Off., 1984.

[45] Beckler, David Z. The Precarious Life of Science in the White House. Daedalus, v. 103. Summer 1974: 116–117.

[46] Beckler, op. cit., p. 118.

Its establishment was also intended to provide a more direct relationship between the Committee, the President, and the Special Assistant for Science and Technology which had been created by President Dwight D. Eisenhower on November 7, 1957. The PSAC had a major influence on security issues during the term of President Eisenhower according to Beckler, who catalogued the following examples of PSAC influence on military policy and programs:

> —the creation of NASA as a civilian space effort to build on the foundation of the National Advisory Committee for Aeronautics;
>
> —the establishment of the Director of Defense Research and Engineering as the number three man in the Department of Defense;
>
> —major improvements in the long-range ballistic missile program, including new emphasis on solid propellant engines;
>
> —the acceleration of ballistic missile early warning capabilities;
>
> —major advances in our technical capabilities for antisubmarine warfare and photographic intelligence gathering;
>
> —recommendations that led directly to the establishment of the Arms Control and Disarmament Agency; and
>
> —assessments of the desirability and technical feasibility of a nuclear test ban which led, in the Kennedy Administration, to the successful consummation of the atmospheric test ban treaty. . . .[47]

In a memo written in 1969, twelve years into the history of PSAC, Richard L. Garwin, a physicist who served two terms on PSAC, concluded that PSAC provided a measure of independent advice on DOD programs and policies and on broader security issues which may be missing from other military advisory panels.[48] He identified some major influences of PSAC and the President's science advisor on military activities: work on biological warfare/chemical warfare policies which shaped presidential policies; development of technology to ensure adequate safeguards against accidental or unauthorized launch of U.S. missiles in Europe; background work to develop fast deployment logistic ships, FDL, as alternatives to the C–5A aircraft; and enhancement of the night vision capabilities of U.S. armed forces in Vietnam.[49] Garwin reported that while neither science advisers nor PSAC members were members of the National Security Council (NSC), science advisors often participated in NSC meetings in a smooth working partnership with the military especially when the people involved had worked together closely during military hostilities.

Thereafter, it appears that NSC members began to perceive that most science advisors held views opposite to the views of most NSC members.[50]

During the Johnson and Nixon Administrations the science advisory apparatus did not have a significant impact on Vietnam deliberations, because the science advisor lacked direct access to the

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[47] Beckler, op. cit., p. 118.
[48] Garwin, op. cit., p. 117.
[49] Ibid., p. 116–117.
[50] Weisner, Jerome B. Science and Technology: Government and Politics. In Golden, William T., ed. Science Advice to the President. New York, Pergamon Press, 1980, p. 37.

President on security and other issues and the NSC staff had grown so large.[51] However, apparently the DOD viewed the science advisor and the OST apparatus as an independent source of advice, sometimes useful and sometimes as an unwelcome interference. Herbert York, who had been the first Director of Defense Research and Engineering in DOD and who had been a member of the President's Science Advisory Committee during the Eisenhower presidency, and a co-author have concluded that the demise of PSAC in 1973 left a significant void in the military research advisory mechanism because:

> Of all the trends and events in the administration of military R&D during the past ten years, surely the decline and demis of the President's Science Advisory Committee is the most important. The only effective "check and balance" operating in the military R&D system has been removed by eliminating the only inside group which had access both to information and power and which, at the same time, was composed in the main of persons not having a vested interest in some major element of the program.[52]

The eventual termination of PSAC (which was effected via the submittal of Reorganization Plan Number 1 of 1973), which occurred in the first Nixon Administration has been attributed to positions taken by its members or consultants and by former science advisors in opposition to President Nixon's policies for deployment of an antiballistic missile system and other policies regarding the Vietnam War and the SST.[53] A new Office of Science and Technology was recreated pursuant to passage of P.L. 94-282, "The National Science and Technology Policy, Organization, and Priorities Act of 1976." PASC was not restored.

During the Carter Administration the Office of Science and Technology Policy appeared to be involved only peripherally in several publicly discussed military R&D and technology issues. In 1978 the OSTP issued the "Galt Report," the Report of the Working Group on Basic Research in the Department of Defense, which called, among other things, for increased military support for basic research at colleges and universities.[54] Dr. Frank Press, President Carter's science advisor, described the scope and utility of several other types of advice rendered by the OSTP on military issues that did not necessarily result in published reports:

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[51] Beckler, op. cit., p. 120.

[52] York, Herbert F. and G. Allen Greb. Military Research and Development: A Postwar History. Bulletin of the Atomic Scientists, Jan. 1977: p. 26.

[53] Beckler, op. cit., pp. 124 and 127. David Beckler, who had been executive officer of PSAC, wrote "In Reorganization Plan Number 1 of 1973 and in the related Congressional hearings, the administration claimed that it disbanded the mechanism mostly in order to streamline the White House staff, and to delegate specialist functions to the agencies where there are more adequate resources." He identified the following as factors which "loomed in the background of the final judgements underlying the hasty decision [to terminate the apparatus:] ". . . the cumulative effect of the years of strain between the White House and the academic and intellectual community over the Vietnam war;" the White House's disappointment with the "New Technological Opportunities" program, developed with the aid of OST; the belief at OMB and the White House that OST/PSAC was "input" rather than "output" oriented; and the belief that OST/PSAC was oriented to basic science rather than technological initiatives. (See Beckler, op. cit., pp. 127-128.)

[54] Report of the Working Group on Basic Research in the Dept. of Defense. OSTP, June 1978, 23 p. (NTIS PB-290 758.)

> Frequently, the President asks me to assemble committees of prestigious scientists and engineers from outside the government to provide independent advice on key national security issues. The President has used their advice in making final decisions on a variety of issues and, when appropriate, committee reports have been given to government agencies to use in shaping policies and programs. For example, OSTP convened a high-level panel to compare and assess U.S. and U.S.S.R. technologies in such areas as computers, nuclear warheads, space, battlefield weapons, and high-energy lasers. The President's initial review of the U.S. defense posture incorporated this panel's findings. At a late stage, the President asked for a review of the vulnerability of U.S. strategic weapons systems to an expanding Soviet missile threat. That panel's findings were considered by the President in decisions on U.S. strategic modernization efforts such as the Trident, cruise missile, and M-X intercontinental ballistic missile programs. Regarding the complex M-X issue, the panel advised the President on several alternatives to our current Minuteman system and on the underlying environmental, military and arms control implications.
>
> OSTP participates in a wide range of NSC arms control reviews, many of which involve difficult technical questions. For example, a senior member of the OSTP staff chairs the NSC interagency working group on the Comprehensive Nuclear Test Ban (CTB) and has also chaired NSC working groups on the U.S. nuclear test program and other arms control issues. OSTP frequently convenes outside panels to support these activities. For example, a panel was convened to review the relative impact of a halt in testing on both U.S. and Soviet capabilities and to consider special verification procedures and other provisions to support the CTB negotiations.[55]

During the Reagan administration, important advice on military policy and specific programs for R and D and weapons development has been rendered by the President's science and technology advisor, the White House Science Council, a group of 13 scientists and technologists (mostly physicists) created to advise the Science Advisor, and ad hoc groups and commissions created to deal with specific activities. The main advantage of the President's science and technology advisor and his staff in the White House Office of Science and Technology Policy (OSTP) is that it can take a broad national as well as interagency perpective on issues, to supplement or complement the narrower view taken by the DOD and its advisory groups. The agency helps to coordinate and mediate different agency perspectives. During the Reagan Administration the OSTP has played a lead role in several interagency groups and ad hoc panels with military implications, including those dealing with supercomputer research (DARPA); national security and scientific freedom; and stockpile policy. The President's first science advisor, George Keyworth, played important roles in implementing plans for the Strategic Defense Initiative, a program created in 1983, and in developing plans for the transatmospheric vehicle, a program initiated during the fiscal year 1987 budget cycle. The White House Science Council and the OSTP created several panels which reported on specific military R&D issues, including the Panel on Future Military Technologies and the Aeronautical Policy Review Committee, which recommended methods for keeping the U.S. aerospace industry competitive internationally and militarily competent.[56] A science council subcommittee, headed by David Packard, reported to the President on the state of Federal laboratories and university facilities and funding. In addition, the President's Private Sector Survey on Cost Control (the Grace Commission) dealt with several issues of DOD management and production and the recent Packard report, of the President's Blue Ribbon Commission on Defense Management, made recommendations regarding reform of DOD R&D management and operations. (See chapter IV.)

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[55] Press, Frank. Science and Technology in the White House, 1977 to 1980: Part 2. Science, v. 211, Jan 16, 1981. p. 252

## H. CONCLUDING OBSERVATIONS

The Defense Department has established a series of advisory bodies composed, for the most part, of nongovernmental scientists and technologists to render advice on priorities, management, policy and overall program directions. These bodies may be a useful source of objective expert information because they are not involved in the immediate day-to-day details of decisionmaking. Yet their very comparative advantage may compromise their utility because these nongovernmental experts are experts by virtue of the fact that they work for firms and universities that provide services to the military, and thus they may be subject to conflicts on interest. Various congressional groups have examined this problem; and the DOD says it has taken steps to alleviate any problems of bias and conflict of interest.

It is difficult to provide an objective assessment of the utility of the work of the Defense Science Board and related bodies without undertaking a comprehensive analysis of their activities. This chapter did not do that; instead it summarized some of the secondary literature relating to these bodies. On this basis, it is generally acknowledged that the Defense Science Board and the Services' advisory bodies render important advice on many issues. This advice is subject to the constraint that it will probably be used only if sought, and that the defense scientific advisory groups most usually react to problems rather than develop policy on an anticipatory basis. Advice on military scientific and technical issues is also provided by other bodies and White House advisory groups.

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[56] Science Advisors Cite Research Need. Aviation Week and Space Technology, Sept. 3, 1984: p. 178. The studies referred to are: Aeronautical Research and Technology Policy, v. I: Summary Report, OSTP, Nov. 1982. 41 p. and v. II: Final Report, Nov. 1982.

# CHAPTER XII

## DOD SCIENTIFIC RESEARCH ACCOMPLISHMENTS AND THE IMPACT OF MILITARY RESEARCH ON SCIENCE*

It is very difficult to measure the benefits of research results generated by DOD funding. One of the major obstacles to effective quantitative analysis of the effects of research investment in science generally is the absence of good models to identify and measure the value of outputs in relation to investment inputs.[1] However, according to DOD:

> One could count the number of published journal articles resulting from DOD-sponsored research, or the number of literature citations received, or the number of patent applications, or use any of a dozen other metrics, and then drew conclusions based on these statistics.[2]

Another statistic often cited as a measure of utility by the Department of Defense is that ". . . nearly 20 Americans . . . have received Nobel prizes this past decade [1975 to 1985] while working on DOD-supported programs." [3]

This chapter discusses the contributions of DOD science in terms of its influence on enduring patterns and practices in the Government/science support relationship, whether it has generated "spinoff" of commercial value, whether military R&D has served as an agent of technological change, whether it broadens the storehouse of general scientific knowledge.

### A. INFLUENCE ON THE FORMULATION OF THE GOVERNMENT/SCIENCE SUPPORT RELATIONSHIP

As noted above in Chapter III, historically the military gave a significant impetus to American science, to the formulation of the university research structure, and to the development of most programs, policies, and fundamental expectations in the Government/science relationship which continue today. Roger Gilpin summarized this view:

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*Prepared by Genevieve J. Knezo, Specialist in Science and Technology, Science Policy Research Division.

[1] On this point, see: U.S. Congress. Office of Tehnology Assessement. Research Funding As an Investment: Can We Measure the Returns? A Technical Memorandum. Washington, U.S. Govt. Print. Off., 1986, 72 p.

[2] Department of Defense. Basic Research Program, Sept. 1985, op. cit., p. 6.

[3] Department of Defense. Basic Research Program, Sept. 1985, p. 6. See also: U.S. Congress. House. Committee on Science and Technology. Task Force on Science Policy. Science Policy Study Background Report No. 3. The Nobel-Prize Awards in Science as a Measure of National Strength in Science. Report prepared by the Congressional Research Service, Library of Congress. 99th Congress 2nd sess. Sept. 1986. Washington, U.S. Govt. Print. Off., 1986, 192 p. (Committee print.)

> Contrary to the argument of the critics that basic research in the universities and engineering research became a captive of the military, what one had in effect was an alliance between particular government agencies and particular academic disciplines and institutions of higher learning. During the Second World War, a new generation of American scientists and technologists matured which was dedicated to transforming American university research. They desired American universities and engineering schools to become major centers of research in the advanced areas of science and technology which were then coming into prominence: theoretical and costly experimental physics, polymer chemistry, electronics, aeronautics, and, later solid state physics. For its part, the military and certain other government agencies desired the same type of advanced sciences and technologies. In the name of national security, plentiful funds were available and the government financed a relatively broad spectrum of research in these newer areas, especially in the more prestigious institutions: MIT, Harvard, Princeton, the University of California, the University of Michigan, the California Institute of Technology, and so forth. Scientists and engineers were relatively free to pursue their own research interests because the interests of the military services, the Atomic Energy Commission, and the National Aeronautics and Space Administration were sufficiently broad to encompass whatever came out of the university laboratories.[4]

There is also the view that the military support of research led to the development of certain research practices which continue to guide science policy today. These were described in detail in chapter III. One of the major and often cited impacts consists of the practices and policies of the Office of Naval Research (ONR) and the legacy for Federal support patterns of ONR's early determination to support basic research and its aftermath:

> Under this philosophy ONR rapidly became the mainstay of much of American science, especially physics and electrical engineering, and to a lesser extent chemistry, metallurgy, mathematics and geophysics. ONR also continued to follow that pattern established in OSRD: support the best researchers and the best research proposals without regard to institutional or geographical considerations. And the judgment of what is best was to be made by scientists in the same general field of work, either as program officers within ONR as outside consulting scientists. ONR very rapidly achieved a high reputation in the scientific community—indeed a reputation that was never quite equalled either by the other military services, which later set up similar agencies, or even by the Atomic Energy Commission or the National Science Foundation. ONR, in fact established the general pattern of operation that was followed by all the postwar research agencies.[5]

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[4] U.S. Congress. Joint Economic Committee. Subcommittee on Economic Growth. Technology, Economic Growth, and International Competitiveness. By Robert Gilpin. 94th congress, 1st session. Washington, U.S. Govt. Print. Off., 1975, 32–33. (Joint Committee Print.)

[5] Brooks, Harvey. Appendix E. Impact of the Defense Establishment on Science and Education. In U.S. Congress. House. Committee on Science, and Astronautics. Subcommittee on Science, Research, and Development. National Science Policy. H. Co. Res. 666. Hearings. July, August and September 1970. 91st Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1970. p. 938.

## B. REPORTS OF SCIENTIFIC AND TECHNICAL FINDINGS

One direct measurement of the accomplishments of DOD-research support programs consists of publications produced by researchers who have received DOD funding. The technical reports of completed research sponsored by the scientific offices of the Services are made available to other researchers, government agencies, Service laboratories, and contractors via the Defense Technical Information Service, DTIC. The Services also periodically publish summaries and lists of the reports sponsored by their scientific offices for use of their laboratory personnel.[6] In addition, the Department and the Services have compiled lists of research accomplishments resulting from their support programs. For instance in a 1985 report on the Pentagon's *Basic Research Program,* the Department cited scientific accomplishments which helped invigorate the military technology program during the period 1983 to 1985:

> Research on computer-generated images has resulted in algorithms which yield more realistic displays under conditions where the sensing rays are scattered by the object, such as in IR, laser, and radar illumination. These algorithms are aiding in the determination of signatures, "hot spots," and battlefield targets.
>
> Halide glass research has pioneered the development of chemically stable gases that transmit light in the infrared region without scattering or attenuating the light. These glasses are improving fiber optic communications and infrared domes, lenses, and mirrors.
>
> A deep-towed (e.g. for 100 meters above the bottom at depths of 6000 meters) geophysical system has been developed and tested which provides significantly better definition of ocean bottom properties.[7]

Each of the Services has also published documents summarizing recent research accomplishments. For instance the Air Force has published a series entitled *Recent Research Accomplishments of the Air Force Office of Scientific Research.*[8] The Navy publishes a series called: *Selected Accomplishments. Office of Naval Research. Sponsored Programs.*[9] The Army's research accomplishments have been described in the *Annual Reports*, by the U.S. Army Research Office.[10] Special separate analyses have also been made from time to time of individual research programs. For instance, a study of three ONR programs, including: (1) Project Whirlwind (basic research in engineering related to design of computer software and hardware); (2) the Laboratory for Nuclear Science and Engineering; and (3) the work of Professor Morris Cohen and 40 graduate students trained with ONR funds, described the subsequent knowledge generated, applications made, companies formed, and "billions" of dollars returned to the Treasury in the form of tax dollars from activities spawned by the initial investments in these three projects.[11]

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[6] See, for example, Air Force Office of Scientific Research. Air Force Systems Command. AFOSR. Technical Report Summaries. January-Mar. 1986, 214 p.

[7] Department of Defense. Basic Research Program, Sept. 1985, pp. 6–7.

[8] See for instance: Recent Accomplishments of the Air Force Office of Scientific Research. Washington, D.C., Bolling Air Force Base, May 1985.

[9] U.S. Office of Naval Research. Department of the Navy. Selected Accomplishments. Office of Naval Research. Sponsored Programs. January 1986. Washington, U.S. Govt. Print. Off., 1986. 83 p.

[10] The most recent issue in this series is: U.S. Army Research Office. ARO Program. Final FY85/Initial FY86 Single Project Funding (SPF) Report. Project Title: Scientific Problems With Military Applications. Research Triangle Park, NC., Oct.. 1985, 262 p.

It is apparent that documents like these do not provide necessarily an objective measure of the accomplishments of DOD-sponsored research. But they do reveal the rich and varied kinds of science supported by the military services. It should be noted however, for about the last twenty years questions have been raised about the appropriateness of DOD's supporting research whose relevance to a military mission might not be readily apparent or research which might be supported more appropriately by a civilian research support agency. (For additional information, see chapter III.)

### C. ARGUMENTS THAT DOD HAS STIMULATED THE GROWTH OF CERTAIN FIELDS OF SCIENCE

There is a widely held view that military funding has nurtured developments in certain fields of science that would not have occurred as readily without the DOD impetus. Such activities include crucial developments in:

psychology (stimulated by the Army's need during World War I to develop techniques to classify recruits for certain technologically oriented tasks),[12]

operations research techniques which " . . . became the intellectual ancestor of a host of new developments in the postwar period with a great impact on business management and public policy,"[13]

social sciences and the study of social systems (stimulated by intelligence requirements of the Office of Strategic Services and other intelligence agencies,[14] and

computer sciences and materials sciences.

On this last point, Brooks wrote:

> . . . The Advanced Research Projects Agency has pioneered in support of the development of computer software and in the development of computer sciences as a new disciplines in universities. It was also ARPA that seized the initiative in following a recommendation of a committee of the Federal Council for Science and Technology to inaugurate a program of long-term support for "materials sciences" in universities.[15]

There is also the view that Federal investments in science and technology drive other kinds of discovery and technological development. Evidence is cited of the strides that were leveraged to drive discovery in scientific research that followed manned lunar probes. By implication, it is argued that DOD investments in R and D, which comprise such a large portion of Federal R and D, should pave the way for technological breakthroughs and developments. The U.S. aircraft industry, it is argued, received its initial impetus from defense work. A new U.S. thrust in advanced aviation technology, including in particular the space plane transatmospheric vehicle, might give the United States a commanding lead over Soviet military aviation, and at the same time would provide the United States with a competitive edge over the established British and nascent Japanese aviation industry.[16] The argument has been made that the current thrust in SDI research will provide the impetus needed for comparable advances. However, others disagree and add that other critical areas of conventional military research may be slighted as funding increases for SDI.[17] This has resulted in congressionally mandated funding increases for conventional defense technology in such areas as aircraft and underwater submersibles. There is also the view, detailed later in this report, that applications of SDI research may not occur as rapidly as hoped and that more research attention, therefore, should be given directly to areas of civilian and commercial application.

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[11] Return on Investment in Basic Research—Exploring a Methodology. Report to the Office of Naval Research, Department of the Navy. By Bruce S. Old Associates, Inc., Concord, Mass. Nov. 1981. 65 p.

[12] Brooks, op. cit., p. 934.

[13] Brooks, op. cit., p. 936.

[14] Brooks, op. cit., p. 942.

[15] Brooks, op. cit., p. 944.

## D. CLAIMS OF SECOND ORDER BENEFITS FROM MILITARY SCIENCE AND TECHNOLOGY

Claims have also been made for spinoff, or transfer and utilization, of military research findings in the civilian sector. These views are summarized in this section. Many analysts have observed that the military has been instrumental in shaping both the scientific and the technological infrastructure of the Nation. In addition to generating scientific and technical information which has been adopted by the civilian sector, military R&D has been credited with laying the foundation for whole sectors of industry, such as aerospace, information sciences, and computer technology, and other specialized electronics sectors. In addition the military is credited with having supported high-risk ventures that the private sector avoided.

### 1. COMMERCIAL "SPINOFF"

There are many claims about the contribution of military research to consumer products. The 1985 DOD report, *Basic Research Programs,* summarized some of these as follows:

> From the time of World War II, the DoD research program has strongly affected our Nation in nonmilitary areas; the developments of radar and synthetic rubber are two prominent examples. From a desire to improve the GI's canned C-rations came new methods for freezing, drying, and preserving food; the printed circuit board found in every inexpensive portable radio evolved from the effort to make proximity fuzes for artillery rounds more

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[16] Beggs Calls for Expanded Aeronautics R&D by U.S. Needed to Save 'Weak' Aircraft Industry. Defense Daily, Nov. 19, 1984: 90–91.

[17] Star Wars Will Devastate More Essential Military Research. Congressional Record. Senate. Feb. 6, 1986: S 1090–S1091.

> gun-rugged; and, of course, there is the ubiquitous laser, with its applications still expanding. Treatements for tropical diseases, cryogenic preservation of blood plasma, improved construction techniques, resuscitators and heart pumps, goggles to aid victims of *retinitis pigmentosa*, and even fluidic lawn sprinklers, have grown out of DOD basic research programs.
>
> Informally, the DOD R&D program weaves itself into the fabric of national life in a pervasive though not always obvious way. The very-high-speed integrated circuit (VHSIC) program now in progress will have a major effect on the electronics industry; VHSIC will eventually enter our lives in ways that will make the wonders of children's talking toys and personal computers seem elementary by comparison. Similarly, work on parallel arrays may profoundly affect the next generation of large computers.[18]

In addition, Naval research on weather balloons has been credited with leading to the commercial development of plastic wrap; Naval development of sonar is claimed to have yielded benefits in the medical area, especially with fetal monitoring; Naval submersibles used originally to map depths are now used for offshore gas and oil mining; and work at the Naval Medical Research Institute on decompression sickness has generated applications to the study of strokes.

The following industrial products have been identified as having benefitted from core military R&D: computers, sonar, radar, jet engines, swept-wing aircraft, insecticides, transistors, fire-and weather-resistant clothing, antibacterial drugs, numerically controlled machine tools, high-speed integrated circuits and nuclear power.[19] Commercial products which have been described as "spinoffs" from military work done at the U.S. Army Research and Development Laboratory at Natick, Mass. include food irradiation—twenty to thirty percent of all food found on store shelves, including specifically freeze-dried coffee, "flaked" minute steaks, and compressed breakfast bars; Goretex water repellant garments; Kevlar bulletproof vests; and many commercial versions of sleeping bags, parkas, gloves and other outdoor clothing sold in sporting goods stores.[20]

## 2. THE MILITARY AS AN AGENT OF TECHNOLOGICAL CHANGE

In a recent study entitled *Military Enterprise and Technological Change; Perspectives on the American Experience*, MIT History of Technological Professor Merritt Roe Smith presented eight case studies which demonstrate the role of the military as an "agent of technological and managerial innovation.[21]

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[18] Department of Defense. Basic Research Program, Sept. 1985, p. 8.

[19] Hattery, Lowell H., National Science Policy and the Element of War, R&D Management Digest, v. 15, no. 4, Oct., 1985: 1, citing: Merrit Roe Smith, ed. Military Enterprise and Technological Change: Perspectives on the American Experience. Cambridge, The MIT Press, 1985, 391 p.

[20] Shell, Ellen Ruppel. Engineering for Survival. Technology Review, July 1982: 14–19.

[21] Smith, op. cit., p. 36.

> Owing to its enduring character, its scale, and its demand for materiel of the highest quality, military enterprise has exerted a powerful influence in determining the institutional and technical dimensions of the modern industrial era. Such influence dates back at least to the eighteenth century and ranges from direct involvement in innovative developments to the indirect sponsorship of technological and even behavioral research.[22]

The subjects of the case studies illustrate some of these achievements including, the application of modern management and mass production techniques, the use of social scientists during World War II, development of initial aspects of the transistor, and the establishment of post World War II scientific research support project mechanisms.[23] Military needs have had profound effects on technological innovation, and, according to Smith, production methods in such areas as: design and dissemination of new technologies; management; and testing, instrumentation, and quality control.

### 3. THE MILITARY AS A TECHNOLOGICAL RISK TAKER

In an historical review, Harvey Brooks, a renowned student of science policy, wrote of the spinoff from military to civilian technology in crucial economic and scientific areas—spinoff often aided by the military's willingness to take economic and technological risks the civilian sector avoided:

> In the evolution of the American scientific establishment one can discern a pattern in which scientific sophistication diffuses outward from military sciences and technology into the civilian economy and into the political and social structure as a whole. This has, of course, been most marked in the period since World War II, when developments in atomic energy, space and electronics have been at the frontier of technological innovation and have moved rapidly from military application to widespread civilian use. The examples are legion: the applications of wartime radar to air traffic control and to microwave communications links, the development of civilian nuclear power and the industrial, and medical applications of radioisotopes, the development of civilian jet aircraft, the computer, solid state electronics and integrated circuits, space communications and weather satellites. In all of these examples, the technology had its origin largely in military applications and the high costs phases of development and even marketing were subsidized by military support, directly and indirectly. In other words, military applications have enabled the technology to surmount the early part of the learning curve, and has provided the confidence in its feasibility and cost which has permitted the private sector to plan with confidence for commercial exploitation.

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[22] Ibid., p. 1-2.
[23] Ibid., passim.

> Military support and testing have been important in the introduction of new technologies which are less obviously related to military application. This is true of many medical developments such as antibiotics and blood preservation, of the introduction of chemical pesticides, of new techniques of industrial air filtering (through subsidy particularly in connection with atomic energy), of power steering in private automobiles or large scale earth moving machinery. In these examples the technology was clearly of civil origin, but its exploration and testing were greatly aided by the availability of military applications or a military market.[24]

James Tegnelia, Acting Director of DARPA, testified before the House Committee on Science and Technology in 1985 on this same point: that DOD support has been especially successful in stimulating the growth of certain technologies during the high-risk phase of development:

> Although the invention of the integrated circuit (IC) did not occur under specific DOD effort, the act . . . leading to it was spurred by the DOD research for "molecular electronics" to reduce the size and power and increase the reliability of electronic systems. Subsequent to the invention of the IC, DOD research played a major role in the early, expensive, high-risk, high-payoff stages (1960–1965) of IC development. Similarly, nickel-based superalloys development by DOD made possible today's military and commercial jet engines.[25]

### E. Questions About Military Research

There is considerable disagreement about the efficacy of current technological spinoffs from the military to the civilian sector. Some argue that military R&D in recent years has resulted in technology too specialized and complex for civilian use. There are also questions about whether the Federal Government should use investments in military R&D as an ad hoc technological innovation policy. In this connection, it is cogently argued that direct funding of technological innovation is a more effective industrial innovation policy than indirect funding.[26] (For more details, see chapter XII.) As noted in Chapter IX the argument has also been made that national scientific and technological capability may be overtaxed by the demands of military R&D which could cause dislocations in civilian R&D and civilian scientific and technical personnel levels. However, there are indications that in some technical areas, supplies of personnel will increase to meet military and civilian needs. This trend may reverse if there is a decrease in the size of the population from which the scientific and technical personnel pool is drawn.

Related to this is the notion that inadequate attention is given to the fact that progress in military science and technology rests on achievements in civilian science and that the military needs to recognize that ". . . Healthy military R&D can flourish only in a healthy overall R&D environment." [27] Thus according to a report of the Georgetown Center for Strategic and International Studies:

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[24] Brooks, op. cit., p. 932.

[25] James Tegnelia, Testimony before the Task Force on Science Policy, Oct. 2, 1985, pp. 1–2.

[26] See Smith, op. cit., pp. 32–37.

> It is very important that the scope and breadth of the national R and D program not be narrowed by a purely military perspective. Many important military capabilities—atomic weapons, high performance jet aircraft, phased-array radar, ballistic and cruise missiles—did evolve within the context of military research and development. But a host of others have derived from civilian R&D—including new materials, lasers, computer sciences, and space exploration—and have contributed significantly to U.S. military capabilities. It is important to recognize that many technologies in the civil sector serve national security objectives directly in their own fashion: Inexpensive telecommunications are an essential element in the modernization of developing countries. In one way or another, most successful technological innovations have a direct bearing on U.S. national security.[28]

This group recommended that greater attention should be given to enhancing the environment for national R&D:

> . . . to focus on money alone without recognizing the other critical consumables and catalysts of a successful R&D process can lead to a distorted view of present and future net national strength, with accompanying opportunity for irreversible error in decisions and reactions. If the R&D base is allowed to deteriorate, the road back to health will be arduous and expensive.[29]

## F. CONCLUDING ISSUES

It is very difficult to measure the impacts of military research in a quantitative fashion. This chapter looked at several historical and some more qualitative assessments. Although there are a variety of opinions about current utility, there is some evidence to indicate that in addition to generating knowledge to improve the quality of weapons and military systems, U.S. military research has, in the past, broadened the storehouse of general scientific and technical knowledge; enhanced the infrastructure of science and laid the foundation for enduringly successful patterns in the Government/science support relationship; stimulated commercial "spinoff;" and generated technological progress and change, especially-in high-risk areas. It has also been claimed that military research efforts have stimulated the growth of certain fields of science.

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[27] Williamson, David, Jr., ed. R&D for National Strength. A Report of the Panel on Science and Technology. Washington, D.C. The Center for Strategic and International Studies. Georgetown University, June 1982, p.3.

[28] Ibid, pp. 1-2.

[29] Ibid., p.3. Also: "Perhaps the most important technological contribution to the modern strategic cruise missile, particularly in the guidance and control system, was the continuing development and application of solid-state microcircuitry wich, although military contributions were not unimportant initially, depended for its current high-volume, low-cost maturity largely on the civil consumer goods sector. Modern microelectronics made its possible to have the required guidance-data storage and accuracy requirements met in a system package in a small, light, relatively cheap and reliable form." (Flax, Alexander H. The Influence of the Civilian Sector on Military R&D. In Long and Reppy, 1980, pp. 113-136.)

Questions have been raised about the cost/effectiveness of investments in military research with respect to civilian spinoff and in view of the fact that 70 percent of the Federal R and D budget supports military missions. Related issues are:

—Should the Government develop direct technology innovation support policies rather than using military R&D policies as ad hoc and indirect inducements for technological innovation;

—Do policy makers give adequate attention to balancing support for civilian and military science?

# CHAPTER XIII

## ECONOMIC IMPACTS OF DEFENSE R&D*

One of the derivative priorities of the Department of Defense (DOD) is the development and maintenance of a healthy civilian scientific and technological base. Although DOD does not have a specific mandate nor delineated program to accomplish this goal, a recent Defense Department report to the Senate Armed Services Committee clearly underscored the Department's view:

> A strong free enterprise economy and industrial base—here and abroad—are the essential underpinnings of our defense posture. Investment in our technology base and maintenance of our technological strength are critical to the long term security of the U.S. and our allies.[1]

While the primary purpose of Federal funding for military research and development (R&D) is to maintain U.S. technological superiority and to provide weapons for the national security of the United States, it is acknowledged that this national security is not and cannot be based solely upon military strength. Also important are the continuation of a high standard of living for American citizens, economic growth and productivity, and the preservation of a strong industrial base. War is not the only threat to the security of the Nation.

It has been argued that ". . . the interdependence of civilian and military research, while politically delicate and socially risky, represents a logical extension of the fundamental purpose of the American military forces: to enhance the security of the American people, their culture and their property."[2] The Defense Department contends that basic research during World War II produced, among other things, ". . . radar, the proximity fuse, nuclear weapons, homing torpedoes, jet aircraft, rockets, and missiles—which changed the conduct of war, and continue to have impact today on the military strength and readiness of the United States."[3] Research conducted during wartime has also provided us with antibiotics, plastics, synthetic textiles, and nuclear energy.[4] It is evident that the research and development undertaken by DOD has impacts beyond that of military preparedness. It has influenced industrial and technological development in a broad range of areas. This section summarizes much of the thinking on the effects of Defense Department support for research and development on the economy. In this context, however, it bears underscoring that the primary purpose of R&D funding by the DOD is to meet the technological needs of defense, not the needs of the civilian economy.

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[1] U.S. Dept. of Defense. Report on the Technology Base and Support of University Research, for the Committee on Armed Services, United States Congress, Washington, DC, Mar. 1985. p. 53.

[2] Cetron, Marvin and Harold Davidson. A Methodology Used to Transfer Future Technology from the Military to the Civilian Evironment. In Davidson, Harold, Marvin Cetron, Joel Goldhar, eds. Technology Transfer. Noordhoff International Publishing, Leiden, 1974. p. 393.

[3] U.S. Dept. of Defense. Basic Research Program. Washington, U.S. Govt. Print. Off. (no date) p. 2.

[4] Browne, Malcolm W. The Star Wars Spinoff. New York Times Magazine, Aug. 24, 1986. p. 20.

## A. R&D and Economic Growth: Theories

Defense-related R&D funding can strengthen national security through the production of weapons and weapons systems. It also supports the pursuit of science and the development of technology which contribute to the country's economic growth by expanding knowledge, by increasing productivity, and by providing new and improved products and processes to meet new and/or previously unmet needs. Indeed, many examples are cited in other sections of this study. If used properly, new processes can allow for more efficient production. New products can meet defense requirements. New materials can reduce our dependence on limited domestic supplies and on other nations. A strong economy can provide the resources with which to support further innovations.

Concerns have been raised as to the impact of defense-related research and development on the economy. Yet, to date, there is little empirical data on the economic effects of DOD R&D spending; most of the available information concerns the effects of Defense Department procurement spending generally. Cause and effect relationships are often hard to establish. Certain theorists argue that the state of the economy is determined primarily by economic factors such as the price and availability of labor and capital. Others stress that technological development and technical knowledge are key factors in stimulating economic growth. John Kendrick found that approximately two-thirds of U.S. industrial growth between 1960 and 1973, measured in real gross product per labor hour, was attributable to technological advances including changes in labor quality resulting from increased education and experience.[5] Work by Edward Dennison concludes that from 1948 to 1973, "advances in knowledge (including technical and managerial knowledge) are the biggest and most basic reason for the persistent long-term growth of output per unit input." [6]

Technological advance generally occurs through innovation. As used here innovation is a process which involves various components including idea origination, research, development, commercialization, and diffusion throughout the economy. It is not necessarily a linear process and an idea can become an actual innovation without evolving though these steps. An invention becomes an innovation when it has been significantly integrated into the economy such that it can be sold in the marketplace to generate income or can be applied in manufacturing to increase productivity. Oftentimes innovations are not the result of a technological opportunity but rather the result of a perceived or potential market need.

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[5] Kendrick, John. Sources of Growth in Real Product and Production in Eight Countries, 1960-1973. New York Stock Exchange, 1981.

[6] Dennison, Edward. Accounting for Slower Economic Growth. The Brookings Institution, 1979. p. 79-80.

Research and development are two particularly important components of the innovation process. Substantial literature has documented the contribution of R&D to a country's economic growth and standard of living. Growing industries—those which are generating new jobs and income—tend to have relatively high rates of investment in R&D.[7] In addition, productivity growth in an industry or firm is directly and significantly related to the amount spent previously on R&D by that industry or company.[8]

Another factor which apparently plays a role in economic growth is the composition of the research which is performed. Basic research is usually undertaken with little certainty as to any future results. Yet it appears that there may be significant positive relationship between the amount of basic research a firm conducts as part of total R&D spending and increases in a firm's productivity.[9] In addition, applied research and development are often necessary to generate a marketable product, process, or service. Because economic benefits accumulate when new or improved products or services are sold in the marketplace, or new or improved processes can be used to increase productivity, these activities contribute to economic growth. The "D" in R&D—development—is quite different from research and it is not reasonable to expect that the two are linked in a linear fashion.

The Department of Defense supports research and development within industry, universities, and Federal laboratories. Most of the DOD R&D budget is for development activities. However, the actual mix of performers has fluctuated somewhat over time and the links between basic scientific research results and the development of new technologies are complex and involve time lags which complicate efforts to identify causal relationships. The balance and composition of DOD R&D activities have effects which require further examination.

### 1. ECONOMIC EFFECTS

The acknowledged contribution of research and development to economic growth, coupled with the large amount of Federal funding for military R&D—relative both to the total national R&D endeavor and to total Federal R&D activities—raises concerns about the impact of such efforts on U.S. economic growth. The Federal Government funds 47 percent of the total national research and development effort; defense-related R&D is over 70 percent of the total Federal commitment. Therefore, federally-funded, military-related research and development is approximately 33 percent of the Nation's R&D activities. This does not take into account direct private sector funds which are expended to develop the infrastructure necessary to meet the R&D and procurement needs of the Defense Department.

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[7] Atkinson, Richard. The Role of Research and Development in Economic Progress. In U.S. Congress. House. Committee on Science and Technology. National Science and Technology Policy Issues. Washington, U.S. Govt. Print. Off., 1979. p. 24.

[8] Mansfield, Edwin. How Economists See R&D. Harvard Business Review, Nov.-Dec. 1981. p. 98.

[9] Mansfield, Edwin. New Findings in Technology Transfer, Productivity, and Economic Policy. Research Management, Mar-Apr. 1983. p.16.

Concerns are being expressed that the United States is loosing its technological lead and competitive advantage relative to past levels of performance and to other industrialized or industrializing nations. The large portion of Federal funds which are dedicated to defense-related R&D and the extent of private sector involvement in the development of military-oriented goods and services focuses attention on determining the impact of these endeavors on economic growth in the United States.

It has been suggested by critics that the sheer magnitude of defense R&D expenditures (most of which are for development) and their rapid recent growth, may have negative impacts on the U.S. economy in terms of slowed productivity growth and diversion of resources from the civilian economy. While R&D within the Defense Department grew 84 percent between 1981 and 1986 (measured in constant dollars), Federal civilian R&D expenditures decreased 16 percent.[10] Thus, there is criticism that Federal support for defense-related R&D diverts resources, both monetary and human, from civilian-oriented work which is more relevant to the marketplace where it can contribute to economic growth.

It is not clear however, that Federal, non-defense R&D spending is more economically relevant and stimulative than defense R&D. The Federal Government traditionally funds R&D in those areas which meet the mission requirements of the Government. It also tends to support those research and development activities which are not being performed in the private sector, primarily because they are not perceived to be commercially viable or profitable. Yet, successful innovation tends to be tied to market considerations, where products and processes are developed to meet or create a market need. Thus, Federal funds tend to support R&D activities which do not particularly take into account the demands of the civilian marketplace.

Much of the critical interest expressed over military R&D spending arises from a question of how much defense-oriented research and development activities can help the Federal Government to fulfill its responsibilities for the well-being of the United States through economic growth, the development of a strong industrial base, and the provision of a high standard of living. One view is that defense-related R&D funding is an inefficient way to achieve this objective. Mary Acland-Hood argues that ". . . military R&D is rarely a successful route to economic and social benefits." [11] There is a conviction that funding dedicated to civilian R&D interests is more effective in meeting these national goals and in meeting the demands of the domestic and international marketplace.

There are critics who maintain that sustained increases in defense spending, as well as for DOD research and development, can adversely affect the private sector economy by crowding out private investment, causing wage or price inflation in certain markets, or encouraging economically inefficient allocaton of the Nation's resources. Decisions to support military-related R&D ". . . distort what would be the normal market allocation of resources, affecting everything from engineering school curricula to profits and investment rates" according to the Center for Defense Information.[12] Because Federal funding for military research and development is so large relative to other Government R&D support, and because Federal R&D spending is concentrated in only a few fields (aircraft and missile development and electrical equipment—including communications equipment and electronic components), private sector resources may tend to converge in these areas. Federal funding for defense-related R&D and procurement of the resultant goods and services helps to ensure the availability of jobs in certain sectors and encourages industry to focus its resources on efforts to meet Federal needs. This may cause the diversion of investment funds into defense-related industries and away from civilian-oriented work. The scale and effects of any such diversion, however are in dispute. It is by no means clear in any case, that resources not expended in defense R&D would be used for market oriented innovation and that funds not expended for defense procurement would be allocated to optimally productive economic enterprise.

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[10] U.S. Congress. Senate. Joint Economic Committee. Technology and Trade: Indicators or U.S. Industrial Innovation. 99th Cong., 2d Sess., Washington, U.S. Govt. Print. Off., 1986. p. 12.

[11] Acland-Hood, Mary. Military and Civil R&D Expenditure. In Science and Public Policy, v. 13, Feb. 1986. p. 52.

### 2. PRODUCTIVITY EFFECTS

Defense R&D generally is not directed at improving private sector productivity. However, whether or not it does have positive or negative effects on productivity is an issue that has been raised in light of concerns over the competitiveness of U.S. industry in world markets. Data on total defense spending and long-term trends in productivity provide "mixed evidence on the relationship between defense spending and trends in productivity growth," according to a Congressional Budget Office report.[13] This report noted that, while international comparisons with Japan, West Germany, France, Canada, and the United Kingdom seem to support the notion that high defense spending retards productivity growth, the data alone cannot establish a causal link between the level of defense spending and productivity gains because they do not isolate the effects of defense spending from other factors such as capital accumulation and the training of labor.

Critics maintain that the use of resources for military research and development in the private sector is not as productive as resources used by industry for civilian-oriented activities. It has been estimated that the military spends ten to twenty times the R&D input per unit of output as the civilian sector.[14] John Linvill and C. Lester Hogan found that in the electronics industry—

> It is probable that government-sponsored R&D in the industry itself was not as productive as the R&D which the industry chose to support itself. The reason for this is simply motivation. Government-sponsored R&D usually demands production of final devices that might or might not be considered useful (that is profitable) for the company in-

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[12] Center for Defense Information. Military Research and the Economy: Burden or Benefit? The Defense Monitor, v. XIV, 1985. p. 2-3.

[13] U.S. Congress. Congressional Budget Office. Defense Spending and the Economy, Feb. 1983. p. 38-41.

[14] Acland-Hood, Military and Civil R&D Expenditure, p. 53.

> volved. If the company chooses to sponsor R&D itself, then it is highly motivated to direct this R&D effort into products that it feels will be profitable to the company.[15]

Similarly, Simon Ramo contends that Federal funding for defense (among other things) ". . . has less direct effect on productivity than private industry spending on technological advance, even though government programs occasionally provide important offshoots." [16]

### B. INDUSTRIAL POLICY

To date, the United States does not have a specified industrial policy. The current Administration argues that such a policy would constitute unwarranted, and inefficient, Government interference in the private sector. However, various analysts contend that choices made regarding defense spending in actuality constitute industrial policy. According to the Center for Defense Information, "the military's research program represents an ad hoc industrial policy." [17] Similarly, Robert DeGrasse, Jr. argues that, "military R&D has been the Federal Government's largest mechanism for influencing technological growth." [18] The determination of where Federal funds for defense-related activities are to be spent can influence the scope and direction of some industrial activities in the private sector. Thus, some decisions pertaining to the dispension of industrial resources are based upon Federal policies and practices.

Research and development funding by the Department of Defense is directed at a limited number of industries. Data furnished by the National Science Foundation show that in 1983, 25 percent of Federal R&D funding for industry was expended in the electronics sector and 51 percent was invested in aircraft and missile development. The concentration of Federal dollars in these areas can influence affected industries to make decisions which are reflective of Government needs. Government requirements often do not coinside with those of the marketplace. Yet substantial segments of industry may choose to focus their resources in sectors which meet Federal requirements for goods and services because of the availability of Government funding and ready markets. Thus Federal spending may become a de facto determinant of which industries and/or which areas of research and development will be supported by the private sector.

### C. INNOVATION

As noted previously, innovation is a multidimensional process by which an idea becomes a product or process which can be sold in the marketplace to generate income or applied in production to increase productivity. It often involves idea generation, research, development, commercialization, and diffusion into the economy. However, it is not necessarily a linear process, and innovations may result from other activities. Economic benefits accrue when a technology or technique is effectively diffused in the marketplace.

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[15] Quoted in Utterback, James and Albert Murray. The Influence of Defense Procurement and Sponsorship of Research and Development of the Civilian Electronics Industry. Cambridge, Center for Policy Alternatives, MIT, June 1977. p. 24.

[16] Ramo, Simon. America's Technology Slip. New York, John Wiley and Sons, 1980. p. 47.

[17] Center for Defense Information, Military Research and the Economy: Burden or Benefit? p. 2.

[18] DeGrasse, Robert Jr. Military Expansion Economic Decline. New York, M. E. Sharpe, Inc., 1983. p. 79.

Innovation is one important factor in America's international competitiveness. Of interest therefore is the impact of defense-related research and development on innovation in the United States. There are numerous examples of DOD supported R&D resulting in innovations as discussed above. James Utterback and Albert Murray found that defense sponsored R&D within the civilian electronics sector prompted companies to produce more rapidly and ". . . led to dramatic increases in the performance and reliability of electronic components and equipment." [19] They also concluded that DOD funding stimulated the entry of new electronic firms into the marketplace, primarily through direct spending, the provision of an initial market, and payment of premium prices.[20] As David Blond argues, "increasing levels of expenditures force the pace of progress by encouraging experimentation with new concepts—with government's money, not with industries. . . . Without radical innovation, Western civilization, built as it is on a dwindling resource base, will stagnate and decline." [21]

The enhancement of the "tech base" is of significant importance to the economic well-being of the United States. This "tech base" is composed of a scientific and engineering infrastructure which includes universities, Federal laboratories, and industrial R&D facilities. It involves the cultivation of knowledge and know-how on which technology development and innovation depend. The contribution of DOD funding to the development of the tech base includes support of basic research in Federal laboratories and in universities; financing industrial development and marketing of new products and processes; encouragment of technology transfer; and the training of manpower through funding of universities, hiring at Federal laboratories, and contracts with industry. While some evidence shows that DOD R&D spending is not as effective in meeting civilian interests as market-based, commercial R&D, other evidence concludes that this does not preclude a substantial contribution by defense-related R&D to the technical and knowledge infrastructure of the country.

The innovation process is often risk intensive. Federal funding for research and development diminishes, if not eliminates, many of the risks associated with the R&D endeavor. Investments in basic research do not guarantee innovative results. Development and commercialization costs are generally the most resource intensive components of the innovation endeavor; undertaken again without assurances as to the results. The assumption of these risks by the Federal Government—through funding the effort and by providing a ready market for the final technology or process—may permit and/or encourage increased creativeness and innovative behavior on behalf of the firms involved.

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[19] Utterback and Murray, The Influence of Defense Procurement and Sponsorship of Research and Development on the Development of the Civilian Electronics Industry, p. 3.

[20] Ibid., p. 3.

[21] Blond, David. The Impact of Defense Spending on the American Economy. Presentation to the Sixteenth Annual Department of Defense Cost Analysis Symposium. Arlington, VA., Oct. 1981. p. 10.

Department of Defense funding for research and development tends to be concentrated in terms of numbers of performers (universities, industry Federal facilities), in disciplines, and within geographic regions. For example, a recent study by Edward Malecki showed that DOD RDT&E performed in industry tends to be concentrated in ten states (California, Massachusetts, Missouri, Florida, Washington, New York, Maryland, Kansas, Virginia, and Texas) which receive 76 percent of the funds. Over half of Defense Department intramural R&D occurs in five states: California, Maryland, Ohio, Virginia, and New Jersey.[22] This concentration may facilitate innovation in these States. The experiences of Silicon Valley in California and Route 128 in Massachusetts seem to demonstrate that, when conditions are right, high technology companies in close proximity can stimulate the spin-off and development of new firms ready to compete or to generate new products and processes. The concentration of scientists and engineers, a stimulating and competitive environment for research and marketing, and the availability of funding can combine to create an environment conducive to innovative activity.

It is also of interest to note that many of those sectors where the United States has traditionally had a favorable trade balance are those which reflect Federal support for mission-oriented R&D. As stated previously, 25 percent of Federal R&D funds are expended in the electronics sector and 51 percent for aircraft and military development. "It is not simply coincidental," Blond argues, "that those sectors of the U.S. economy so far able to compete best on world markets—commercial aircraft (DOD share 39 percent to 57 percent); micro-computers and semi-conductors (9 percent to 15 percent); and industrial electronics (33 percent)—are also those selling significant amounts to the Department of Defense." [23]

However, there are potential negative effects of the Defense Department's R&D funding on the innovative capabilities of U.S. industry. The Government of the United States funds a larger portion of national R&D than many industrialized countries with the exception of the United Kingdom and France. In particular, 98 percent of funding for industrial R&D activity in Japan is generated by industry; in West Germany, 82 percent of industrial R&D financing comes from the private sector (1982). In contrast, only 68 percent of U.S. industrial R&D financing is generated by industry sources (1982), increasing the potential opportunities for governmental influences on decision-making within the private business sector.[24]

As was discussed above, most successful commercial innovations are the result of market demands. However, Federal R&D is not geared to the marketplace, thus decreasing the likelihood of it resulting in successful commercial innovation. Government generally funds research and development which is not being performed in the private sector—often because it is seen as unprofitable. Because the Government tends to be the primary purchaser/user of the results of federally-sponsored R&D, Federal funding for industrial research and development may preclude the development by industry of a product or process for the marketplace.

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[22] Malecki, Edward J. Federal and Industrial R&D: Locational Structures, Economic Effects and Interrelationships. Dept. of Geography. University of Oklahoma, 1983. p. 88-126.

[23] Blond. The Impact of Defense Spending on the American Economy, p. 5.

[24] Joint Economic Committee, Technology and Trade: Indicators of U.S. Industrial Innovation, p. 74.

Innovation requires that a new product or process be diffused into the market and utilized. That is where the economic benefits accrue. However, the argument has been made that it is in the application and commercialization of technology that U.S. industry falls behind our competitors. As was noted by the Center for Defense Information, "the major problem is not that the U.S. lacks advanced technology, but that it fails to apply that technology effectively in commercial production." [25] A new technology or technique must be manufactured or applied in production to become an innovation; however, because the Federal Government does not manufacture, this generally fails to occur. The necessary interaction with, and integration in, the commercial market generally does not take place when the Government sponsors technology development, thus limiting the innovation potential of federally-funded R&D efforts. The President's Commission on Industrial Competitiveness found ". . . Government funded mission-oriented R&D is not a major contributor to industry's ability to innovate and produce." [26]

This situation is further complicated by the fact that most Federal R&D funding (particularly that of the Department of Defense) is directed at the development of products rather than at process technology (equipment and techniques used in the manufacture of goods). The concentration on weapon systems and other defense hardware has tended to inhibit work in process technologies which are often necessary to improve manufacturing productivity; important in both the military and civilian sectors. It is precisely in the area of process innovation that industries in the United States are behind several of the other western industrialized nations, particularly Japan. Seymour Melman contends that the U.S. machine tool industry is loosing out to Japanese imports because it has focused on the production of computer-controlled equipment for the aerospace industry while Japanese industry has concentrated on computer-controlled equipment for smaller commercial markets which, when totaled, are three times the size of the aerospace market.[27]

The fact that defense R&D is more concentrated in States outside the industrial Midwest and Northeast, as noted previously, makes it unlikely that significant increases in military-related research and development will act to directly ameliorate the effects of structural declines in the traditional manufacturing industries or regions. However, efforts are now being made by State and local governments to use the technical and manpower resources of DOD laboratories to enhance local economic growth. Also, recent Defense Department initiatives such as the Manufacturing Technology and

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[25] Center for Defense Information, Military Research and the Economy: Burden or Benefit? p. 3-4.

[26] President's Commission on Industrial Competitiveness. Global Competition, the New Reality, v. II. Washington, U.S. Govt. Print. Off., 1985. p. 82.

[27] Thomas, Rich and Doug Tsurvoka. Too Much for Defense? Newsweek, Mar. 1986. p. 52.

Industrial Modernization Incentive Programs might have some spillover benefits in non-defense production facilities.

Department of Defense R&D dollars tend to support work in large, established firms. Yet various studies have shown that small, high technology firms tend to be more innovative than larger companies.[28] The concentration of defense research and development dollars in large corporations potentially can lessen the opportunities for innovation which may occur if small firms were more involved in the R&D activities. However, additional participation by small companies through the Small Business Innovation Research program and the Strategic Defense Initiative may serve to augment the potential for increased innovation in this sector.

Another factor to consider is that while DOD research and development is large and has increased significantly in the last few years, Defense Department spending for basic research itself has not grown as fast as the total for R&D. Basic research is important to innovation because it can provide the fundamental knowledge on which are based new products or processes. The extent of basic research is important to innovation since studies have shown that there is a significant relationship between the amount of basic research a firm conducts as part of total R&D spending and increases in firm productivity.[29] As a percentage of RDT&E, DOD basic research fell from 5.8 percent in 1963 to 2.5 percent (projected) in 1985. The potential economic impacts from basic research alone, therefore, may be smaller than those from the total R&D effort which includes primarily development activities that are closer to production and/or commercialization.

## D. TECHNOLOGY TRANSFER

Problems associated with the transfer of technology from the military to the civilian sectors have prevented much DOD sponsored research from reaching the civilian marketplace. Among the barriers to transfer are the constraints on information which limit access to new ideas, the separation of military-specific activities from other work in many large companies, and pricing practices which make civilian use of technology prohibitively expensive.[30] However, technology transfer can be enhanced by Defense Department interest in the development of a new technology or technique, by Government funding which assumes most of the risks associated with technology development, and by the fact that DOD funding generally is directed at companies with large R&D programs where research has shown diffusion of information and/or innovations to be the most rapid.[31]

Spin-off is a term often used for the transfer of a technology from military to civilian use. Technology transfer is a broader concept delineating the process by which technology developed in one organization, in one area, or for one purpose is applied and used in another organization, in another area, or for another purpose. It is often a long and laborious process which begins with an effort to identify knowledge or technology which is appropriate for transfer and ends when a good or service is made available in the marketplace.

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[28] U.S. National Science Board. Science Indicators—1976. Washington, U.S. Govt. Print. Off., 1977. p. 116 and U.S. Congress. Senate. Committee on Small Business. Innovation Development Act, P.L. 97-219. Hearings, 98th Cong., 2d Sess., Mar. 1984. Washington, U.S. Govt. Print. Off., 1984. p. 8.

[29] Mansfield, New Findings, in Technology Transfer, Productivity, and Economic Policy, p. 16.

[30] Reppy, Judith. Military R&D and the Civilian Economy. Bulletin of the Atomic Scientists, Oct. 1985. p. 12.

[31] Ibid., p. 12.

At times, the concept of actual or potential spin-off from military research and development has been used to justify portions of the large sums of money invested in the DOD R&D endeavor. There have been numerous examples of the successful conversion of military-directed technology and techniques to civilian use including, but not limited to, those in the areas of computers, semiconductors, aerospace, microwaves, medicine, and personnel psychology. Malcolm Browne argues that spin-offs from the DOD Strategic Defense Initiative ". . . seem destined to change the world." [32] He notes that the Business Communications Company has estimated that the commercialization of SDI technologies will eventually result in private sector sales totalling between $5 and $20 trillion.[33]

Critics argue that spin-off should not be used to justify R&D spending by the Department of Defense. They say the primary purpose of DOD R&D is to provide for the defense capabilities of the United States and that any additional good derived from this effort, while potentially beneficial, is incidential. Lester Thurow maintains that since the outcome of any research is uncertain, and because spin-off can be associated with any type of R&D, spin-off possibilities should not be used as the rationale for funding specific types of military work.[34]

It is also agreed that spin-offs are an ineffective means to meet civilian goals.[35] Ramo notes that the speed and manner of putting technology or technical knowledge to use produces a nation's economic advantage.[36] The nature of the spin-off process is such that it may take longer to use the technology than if it were developed specifically for the civilian marketplace. Utterback and Murray found that in the area of semiconductors most of the innovations were not the direct result of DOD spending.[37] Technology development is stimulated less by direct spin-off than by ". . . the transfer of concepts, components, basic knowledge, and skills gained from defense supported programs. . . ." [38]

Several additional reasons have been put forth to support the idea that spin-off may not be an effective means to generate technological development. As noted above, research has shown that most successful commercial innovations are the result of market demand where a technology or technique is designed to meet an unmet need of the marketplace. Spin-offs however, tend to be the result of technology "push" whereby a technology is developed and a use for it found simply because it exists rather than because it is needed. It thus can be more difficult to diffuse into the marketplace since a need for the technology must first be created.

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[32] Browne, The Star Wars Spinoff, p. 20.

[33] Ibid., p. 22.

[34] Thurow, Lester. The Relationship Between Defense-Related and Civilian-Oriented Research and Development Priorities. In: U.S. Congress. Joint Economic Committee. Priorities and Efficiency in Federal Research and Development. Committee Print. 94th Cong., 2d Sess., Oct. 1976. Washington, U.S. Govt. Print. Off., 1976. p. 9.

[35] Ibid., p. 10.

[36] Ramo, America's Technology Slip. p. 49.

[37] Utterback and Murray, the Influence of Defense Procurement and Sponsorship of Research and Development on the Development of the Civilian Electronics Industry. p. 2.

[38] Ibid., p. 25.

It has also been argued that the technologies now being developed under the auspices of the Department of Defense are too sophisticated and advanced to have much civilian application. The Center for Defense Information found that "there is little opportunity for military research to produce commercial spin-offs because it is concentrated in the development of prototypes of new weapons. Only a small portion of military R&D spending is devoted to the advancement of general technologies . . ."[39] Much of this technology is overdesigned for civilian use; it is developed to meet operating specifications which would not be necessary in non-defense situations.[40] This overdesign makes the technology too expensive for the civilian market. In addition, there have been few cost constraints and/or considerations in defense-related technical development. This is in contrast to the civilian marketplace where cost is a major factor and thus lessens the potential for the transfer of technology to, and the utilization of, technology in the civilian sector.

Despite acknowledged constraints, the technology transfer activities of the military laboratories are an on-going effort to encourage industry, and more recently universities, to develop further and commercialize the results of DOD sponsored research. In pursuit of mission requirements, the laboratories of the Department of Defense and the services have developed an extensive store of expertise and technologies which may have applications that go beyond the immediate goals or intent. Technology transfer is one mechanism by which to apply this knowledge and these technologies to meet other national needs including: the economic growth that flows from new commercialization in the private sector; the Government's requirements for products and processes to operate effectively and efficiently; and the demand for increased goods and services at the State and local level. The Federal Laboratory Consortium for Technology Transfer, a voluntary organization of almost 300 Federal laboratories, seeks to promote this process. The Consortium began as a Department of Defense initiative in 1972. Its origin can be traced to a July 1971 meeting when, at the suggestion of the Special Assistant to the Deputy Director for Research and Advanced Technology, representatives from eleven military laboratories met informally in an attempt to coordinate their efforts to transfer military-related technologies to the civilian sector. This resulted in the creation of a DOD Laboratory Consortium.[41] This Consortium subsequently was expanded to include laboratories from other Federal R&D agencies and no longer remains within the Defense Department, although DOD laboratories are still active members.

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[39] Center for Defense Information, Military Research and the Economy: Burden or Benefit? p. 2.

[40] Ibid., p. 6.

[41] See chapter VI.

However, to date, the private sector, with a few exceptions, has been reluctant to take advantage of Government efforts to transfer federally-funded technology. It is not clear whether this can be attributed to a lack of interest by industry, to unfamiliarity with DOD research, the "not-invented-here" syndrome, the lack of utility found for commercial application, and/or ambiguities associated with obtaining title to, or exclusive license to, federally-owned patents. Nonetheless, some urge new incentives to foster improved private sector use of the results of DOD supported research. Legislation recently enacted (P.L. 99-502) provides the Federal Laboratory Consortium with a legislative mandate to operate and promote technology transfer as well as encourage cooperative research arrangements between Federal laboratories and the private sector under which companies can use the advanced (and often expensive) equipment in these laboratories and tap the expertise of Federal employees. Increased interaction between the Defense Department and small high technology firms under both the Small Business Innovation Research program and the Strategic Defense Initiative may also help to foster the transfer of research results into the private sector.

## E. Security Classification

Classification of research is intended to impede the transfer of research results to nations and organizations that could be expected to use it to the detriment of U.S. national interests. (See chapter X for more information.) It can also slow both the application of research results to non-defense products and processes and the dissemination of research findings beyond the performing institution. DOD's basic (6.1) research is rarely classified, but 6.2 exploratory development work is more likely to be classified for national security purposes. Because of the open nature of the research enterprise in universities, classification is potentially a more troublesome problem for academic performers than for industrial employees who are more accustomed to dealing with proprietary information.

Enlarging the kinds of research results that should be classified could reduce the likelihood of wide dissemination, particularly outside the defense research community, and could, therefore, impede the utilization of these results in civilian applications. In addition, classification may confer advantages to the originating organization (firm) which may take advantage of dissemination lag times to build upon in-house research before other companies are able to access information about the product or processes. It is therefore possible for defense contractors working in areas with fairly direct civilian applications to gain a competitive advantage over other firms which do not receive DOD research contracts.

Results of DOD development contracts are quite likely to be classified and not available to performers outside the defense community. Although little classified development work is currently being done on university campuses, an increasing use of classification or of national security export controls of heretofore unclassified work funded by the Defense Department could disrupt DOD/university relationships. As Federal support for research in targeted areas increases and if classification of more academic work occurs, it might compel universities and other performers to restructure their interactions with the Pentagon.

## F. EFFECTS ON TRAINED PERSONNEL

An often voiced concern is that increases in DOD research and development would result in the diversion of human resources from civilian R&D, especially if there is a limited supply of technical manpower. According to the CBO report, data describing past R&D spending have suggested that substitution of defense for civilian research and development was not evident. Instead, past increases in defense and space R&D spending (especially during the space race) have been accompanied by increases in private R&D spending, suggesting that the Nation's science and engineering manpower has been able to expand readily in response to increased demand.[42]

However, the current situation involving increased worldwide competition for technically trained labor and a higher base of R&D activity than in the pre-Sputnik era raises the possibility that increasing DOD research and development dramatically might result in bottlenecks or realignments in the U.S. research infrastructure. For example, some observers have complained that large targeted undertakings, such as DARPA's strategic computing initiative, might cause significant changes within the affected research communities in terms of field chosen by new researchers and the direction of new research undertaken.[43] Frank Lichtenberg observed that (recently) an increase in science and engineering employment resulting from Federal R&D contracts has been accompanied by a decrease in the number of scientists and engineers employed in company-financed research and development.[44] Similarly, Otto Eckstein testified at hearings that the defense buildup will divert technical manpower. In addition, he predicted, this will be coupled with budget cuts on the civilian R&D side and with reductions in support for training and fellowship programs for scientists and engineers.[45]

The Department of Defense's funding for industrial R&D activities creates the possibility that defense contractors may divert the best manpower resources away from non-military firms and small, high technology companies which might be in a better position to contribute to innovation in the civilian sector. If salaries in the defense industries tend to be higher on average than comparable salaries in firms which do not rely heavily on DOD contracts, there may be significant disincentives for trained personnel to leave military-related work for opportunities in non-defense research and development. Conversely, if salary levels in certain fields such as microelectronics and advanced computing are much higher in commercial firms than in defense-oriented companies, the best manpower resources may be diverted from military R&D.

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[42] Center for Defense Information, Defense Spending and the Economy. p. 41-42.

[43] See, for example: Assessing the Strategic Computing Initiative. Davis, Swight B. High Technology Apr. 1985. p. 41-49 and Supercomputers and Artificial Intelligence: Recent Federal Initiatives. Miller, Nancy R. CRS Issue Brief IB85105.

[44] Reppy, Military R&D and the Civilian Economy. p. 13.

[45] U.S. Congress. Joint Economic Committee. The Defense Program and the Economy. Hearings, 97th Cong., 1st & 2d Sess., Oct. 81 & Dec. 81. Washington, U.S. Govt. Print. Off., 1983. p. 317-318.

## G. Concluding Observations

Support by the Department of Defense for research and development has various implications for the economic well-being of the United States. Without argument, this effort has lead to the development of various new technologies and techniques which have had profound impacts on our lives. Advances in the areas of medicine, psychology, electronics, computers, and aviation (among others) resulting from military R&D have helped to improve the standard of living of this Nation and its citizens. The R&D program has provided us with military products and processes which contribute directly to our defense. Yet, national security is more than just weapons; a strong citizenry and a healthy economy are also important factors. In many of these areas, DOD research and development spending has served us well. If certain experts are correct, Defense Department funding, particularly that of the Strategic Defense Initiative, may provide economic and social benefits.

The United States is now experiencing competitive problems in high technology trade and productivity. Concerns have been voiced regarding the effects of the Defense Department's efforts on the conduct of civilian R&D and on the economy. The large Federal investment in military research and development in the 1960s did not lead to increased industrial growth in the following years.[46] Subsequent decreases in defense R&D did not bring demonstrable improvement for industrial vitality. Other explanations for this are identified by economists. Further the large role the Federal Government plays in funding R&D in industry, and the concomitant impact of Government policies and practices on decision-making in industry may explain some of the reasons for the difficulties some American industries are having competing in the world marketplace. As noted above, in 1986 the Federal Government funded 47 percent of the total national R&D effort and approximately 32 percent of the total research and development performed in industry. [Over 70 percent of Federal R&D funds are for defense-oriented activities.] Thus, a sizable portion (47 percent) of the funding for R&D within the United States is directed toward Government needs and purposes rather than those of the civilian marketplace. However, there is evidence that most innovation (and the resulting economic growth) is stimulated by market demand or need. The substantial financial contribution of the Federal Government to the support of R&D activities appears to have lead to at least some reduced emphasis by certain industries on the commercialization of technology and its difusion in civilian markets. This is in marked contrast to many of the other Western industrialized nations and the newly industralizing countries of East Asia where governments often sponsor on-going efforts to promote the development of commercial technologies for world markets.

The most significant contribution of military R&D to economic growth and technology development may be the support of the transfer of ideas, skills, methods of research, interest in research and development, and the acceptance of science and technology which has evolved as a result of the pursuit of defense. As the Denver Research Institute maintained, the greatest impact of military technology is the transfer of knowledge about products and processes not the direct transfer of goods and services to the civilian sector.[47] The development of know-how, the support for the training of scientists and engineers, and an understanding of the potential contributions of science and technology to solving problems, all are potentially beneficial to the development of a technologically oriented and technically sophisticated society. Further, defense R&D funding permits scientific risk taking and experimentation with new concepts having potential for major long term benefits, a role often not feasible for private enterprise. Negative impacts of DOD R&D support on economic growth and civilian technological development may be ameliorated if they are recognized and addressed by decision-makers in both the public and private sectors. If Congress determines this to be an objective to be pursued, specific action may make it possible to more effectively harness the Defense Department's funding for research and development to better meet the needs of the civilian marketplace and thereby contribute more to the economic well-being of the United States. However, this must be achieved without weakening the defense objectives of DOD spending for research and development.

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[46] DeGrasse, Military Expansion Economic Decline, p. 80.

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[47] Mansfield, Edwin. The Economics of Technological Change. New York, W.W. Norton and Co., Inc., 1968. p. 255.

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